IPM CRSP Annual Highlights

For Year 8 (2000 - 2001)

Funded by USAID under Grant
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Office of International Research and Development
Outreach Division, Office of the University Provost
1060 Litton Reaves Hall
Blacksburg, Virginia 24061-0334

Virginia Tech
Virginia Polytechnic Institute and State University

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VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

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November 28, 2001

Cover Photographs (top to bottom):

1. Olive orchard in Albania.
2. Fruit and shoot borer damage on eggplant in Asia.
3. Yellow leaf curl virus disease on tomato in Mali.
4. Snow pea quality control and grading in Guatemala.

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IPM CRSP US Institutions

Florida A&M University
Montana State University
Ohio State University
University of Georgia
Penn State University
Purdue University
Virginia Tech
USDA Veg. Lab.
University of California, Davis and Riverside
University of Maryland - Eastern Shore
North Carolina A&T University
Fort Valley State University

Host Country Institutions

Guatemala - Agri-lab, ALTERTEC, ICTA, UVG
Jamaica - CARDI, Ministry of Agriculture
Mali - IER
Philippines - NCPC/UPLB, PhilRice
Uganda - Makerere University, NARO
Ecuador - INIAP
Eritrea - DARHRD
Albania - PPI, FTRI, AUT
Bangladesh - BARC, BARI
Honduras - EAP

International Centers

AVRDC - Taiwan
CIAT - Columbia
CIP - Peru
ICIPE - Kenya
IRRI - Philippines
IFPRI - USA

Private Sector

The Kroger Company PICO Caito Foods

NGOs/PVOs

CLADES; GEXPRONT, Guatemala; CARE, Bangladesh

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The purpose of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) is to develop and implement a replicable approach to IPM that will help reduce: 1) agricultural losses due to pests; 2) damage to national ecosystems; and 3) pollution and contamination of food and water supplies. The goals of the CRSP are to develop improved IPM technologies and institutional changes that will reduce crop losses, increase farmer income, reduce pesticide use, reduce pesticide residues on export products, improve IPM research and education program capabilities, improve ability to monitor pests, and increase the involvement of women in IPM decision making and program design.

Working towards this goal the IPM CRSP follows the following specific objectives:

- Identify and describe the technical factors affecting pest management.
- Identify and describe the social, economic, political, and institutional factors affecting pest management.
- Work with participating groups to design, test, and evaluate appropriate participatory IPM strategies.
- Work with participating groups to promote training and information exchange on Participatory IPM.
- Work with participating groups to foster policy and institutional changes**.**

The research activities of the IPM CRSP are based on close collaborations between scientists of the participating host countries and US institutions. The participating host country sites of the CRSP during Year 8 included Albania, Bangladesh, Ecuador, Guatemala, Honduras, Jamaica, Mali, The Philippines, and Uganda. Among the active partner US institutions are: University of Georgia, Montana State University, Ohio State University, Penn State University, Purdue University, U.C.-Davis and Riverside, University of Maryland - Eastern Shore, North Carolina A&T University, Florida A & M University, Fort Valley State University, USDA, and Virginia Tech (VT) with VT as the lead and the Management Entity (ME) institution.

This report highlights the activities of the CRSP during Year 8 of its operation. The main part of the report is a presentation of the CRSP's activities by its main regions: East and West Africa, Central and South America, the Caribbean, South and Southeast Asia, and Eastern Europe. This document gives for each active site in a region, description of the collaborative program, IPM constraints addressed, selected research accomplishments, progress made in training and institution building, and networking activities. The remaining sections of the report cover several major activities of the CRSP such as the Board of Directors Meeting, Technical Committee Meetings, External Evaluation Panel Reviews, Trip Reports, and Technical Assistance. Details on each of these topics and other related items can be found in the institutional reports of the Year 8 Annual Report of the IPM CRSP.

The Site Chairs, host country Site Coordinators, collaborating scientists, and the Management Entity contributed to this report. The Site Chairs and host country Site Coordinators during Year 8 were:

West Africa Site in Mali: Keith Moore, Virginia Tech (Site Chair); Kadiatou Touré Gamby, IER (Site Research

Coordinator); Bouréma Dembélé, IER (Site Administrative Coordinator).

East Africa Site in Uganda: Mark Erbaugh, Ohio State University (Site Chair); Sam Kyamanywa, Makerere University (Site Coordinator); George Bigirwa, NARO (Deputy Site Coordinator).

South America Site in Ecuador: Jeff Alwang (Site Chair), Virginia Tech; Carmen Suárez, INIAP (Site Coordinator); Victor Barrera, INIAP (Vice Site Coordinator).

Central America Site in Guatemala: Glenn Sullivan, Purdue University (Site Chair); Guillermo Sanchez, Universidad de Valle de Guatemala (Site Coordinator).

Caribbean Site in Jamaica: Sue Tolin, Virginia Tech (Site Chair); Dionne Clarke-Harris, CARDI (Site Coordinator).

Southeast Asia Site in the Philippines: Sally Miller, Ohio State University (Site Chair); (Aurora M. Baltazar), PhilRice (Site Coordinator)

South Asia Site in Bangladesh: George Norton, Virginia Tech (Site Chair); Rezaul Karim, IRRI Dhaka (Site Coordinator)

Eastern Europe Site in Albania: Doug Pfeiffer, Virginia Tech (Site Chair); Josef Tedeschini, Crop Protection Institute, Durres (Site Coordinator)

In the Management Entity the following contributed to the report:

S.K. DeDatta, Principal Investigator of the IPM CRSP, Director of the Office of International Research and Development (OIRD), and Associate Dean of the College of Agriculture and Life Sciences, Virginia Tech.

Brhane Gebrekidan, Program Director, IPM CRSP, Virginia Tech.

Greg Luther, Assistant Program Director, IPM CRSP, Virginia Tech.

AFRICA REGION

East Africa Site in Uganda

J. Mark Erbaugh, Site Chair, The Ohio State University; Samuel Kyamanywa, Site Coordinator, Makerere University; George Bigirwa, Deputy Site Coordinator, NARO

The Collaborative Program

The IPM CRSP Uganda Site is a collaboration of Makerere University Faculty of Agriculture (MU/FA), the Ugandan National Agricultural Research Organization (NARO), the Ministry of Agriculture, Animal Industries and Fisheries Extension Service, participating farmer NGO groups and scientists from IPM CRSP USA Institutions. The program in Uganda operates under a Memorandum of Understanding with Makerere University Faculty of Agriculture (MU/FA). The in-country Site Coordinator located at MU/FA is Dr. S. Kyamanywa, Department Chairman of the Crop Science Department. He is directly linked to NARO through the Deputy Site Coordinator who is appointed by the Director General of NARO, Dr. Joseph Mukiibi. Dr. G. Bigirwa is the Deputy Site Coordinator, and he is also leader of NARO's Maize Research Team. The IPM CRSP collaborates with research scientists from four NARO research institutes and one sub-station: Kwanda Agriculture Research Institute (KARI), Namulonge Agricultural and Animal Research Institute (NAARI), Serere Agricultural and Animal Research Institute (SAARI), the Kalengyere Potato Research sub-station, and the Coffee Research Institute (CORI).

Currently, the IPM CRSP team in Uganda consists of 6 co-PIs and 4 graduate students from MU/FA, 7 co-PIs from NARO, and 3 extension agents, representing 6 separate disciplines. Collaborating with Uganda co-PIs are eight USA-based co-PIs, representing 4 disciplines from 3 universities: The Ohio State University, Virginia Tech, and Fort Valley State University. The Site Chair, Dr. Mark Erbaugh, The Ohio State University, coordinates this multi-institutional and disciplinary program. The Site Coordinator administers research activities with local co-PIs and extension agents. The Site Chair and Coordinator maintain weekly contact and all co-PIs are encouraged to maintain communication with their respective collaborators on individual research activities.

During this past year, there were several changes to the Uganda IPM CRSP team. With great sadness it is noted that Dr. Harold Willson, Extension Entomologist at OSU and long-time IPM CRSP collaborator with the Uganda Site, passed away in February, 2001. Professor Ron Hammond, Entomology, from OSU, replaces him. As noted above, Dr. Bigirwa resumed his position as Deputy Site Coordinator. Dr. Ajmer Bhagsari, Horticulture, Fort Valley State University retired, and was replaced by Dr. George Mbata. Dr. J.J. Hakiza, formerly Director of Kalengyere Potato Research sub-station and of the National Potato Program was made leader of the National Horticultural Research Program. He remains active with IPM CRSP activities on potato and tomatoes. Dr. Joseph Oryokot, formerly Director of SAARI, took a new job with the National Agricultural Advisory Service. Mr. J. R. Olupot, who completed his M.S. thesis with IPM CRSP support and has taken a job with the Extension Service, is continuing his work on *Striga* management.

The IPM CRSP has emphasized a farmer participatory approach to integrated pest management (PIPM). Dr. D. Plucknettt, the External Evaluation Committee member who

evaluated the Uganda Site this year, stated in his report that "the research process being followed is participatory in all phases, and farmers and researchers are involved in problem identification, research and evaluation". In Uganda, developing linkages with local extension agents has facilitated the PIPM approach. Although the National Extension System is again being reorganized as the National Agricultural Advisory Service (NADS), extension agents affiliated with the IPM CRSP continue to rely on NARO and Makerere scientists for assistance in conducting on-farm research and specialized technology transfer activities. The Uganda Site relies on extension agents to manage scientists and graduate student contacts with participating farmer groups. The number of farmer groups has been expanded to four each in Kumi and Pallisa districts and two in Iganga district. The site continues to cooperate with an informal grouping of tomato growers in Mpigi District. In addition, a pilot IPM training-of-trainers program was conducted with 8 extension agents in Iganga district this year. Each agent in the program set up on-farm demonstration trials of selected IPM CRSP technologies and hosted field days for farmers in their respective areas. Maintaining direct links between scientists and farmers and providing farmers with direct feedback from research activities has been aided by extension agents and working with groups of farmers. However, this remains a constant challenge requiring innovative approaches that merge research activities with information sharing and farmer technology assessment.

The planning and implementation of Uganda Site activities follows the annual calendar of IPM CRSP project events. These activities seek to maximize interdisciplinary and multi-institutional collaboration and provide consistent contact between Site managers and collaborating co-PIs. Planning activities this year began with a one-day meeting held in early February 2001 for six social scientists affiliated with the project. Two USA based co-PIs, Drs. Taylor and Erbaugh, attended this meeting whose main objective was to improve the integration of social activities across all Site activities. This was followed in mid-March with the annual work plan development meeting held in Jinja at which 19 Uganda Site co-PIs and graduate students and 6 USA-based co-PIs attended. Also present at this meeting was Dr. D. Plucknett from the IPM CRSP external evaluation committee. At this meeting brief progress reports were presented, priorities for the next year were discussed, and draft work plans for Year 9 were developed. An addition to the agenda was the presentation of 8 posters by graduate students or co-PIs. The implementation of Year 7 second-season trials began in early April. Research activity trials are implemented during the two rainy seasons: the longer rainy season roughly extends from April through early July, and the short rains extend from September through December. The Year 8 draft was discussed with the Director General of NARO, USAID/Kampala, and the Chief of Party of the USAID funded Investing in Developing Export Agriculture Project (IDEA). A final draft of the work plan and budget was then presented at the IPM CRSP Annual Meeting, held at Virginia Tech in May, 2001. Four of the posters, presented at the annual work plan meeting, were also displayed at the Annual Meeting. Contracting arrangements for the new project on Coffee Wilt Disease were finalized in late July and implementation began in mid-August. USAID/Kampala funds this effort with matching funds provided by the IPM CRSP. A final event in the annual calendar was the Annual Report Preparation Meeting held in Entebbe in mid-September. The purpose of this meeting was to motivate co-PIs to analyze data from the previous two growing seasons; to initiate annual report

preparations; and to discuss journal article preparation and submission. At this meeting co-PIs and graduate students in attendance prepared 18 draft reports. In general, these meetings help integrate research findings, expose research to multi-disciplinary perspectives, and provide an opportunity for discussions of general program implementation.

Finally, planning and implementation of IPM CRSP activities in Uganda continues to involve communication and collaboration with USAID/Kampala, the IDEA Project, the Rockefeller Foundation through the Forum on Agricultural Resource Husbandry, germplasm exchanges with IITA, CIP, ICRISAT/Malawi, and CIMMYT/Harare, and several collaborative interactions with ICIPE. A representative from ICIPE, Dr. Charles Omwega, has attended our last three work plan development meetings. Research collaboration with ICIPE and the Rockefeller Foundation have provided opportunities to cost share graduate student activities at Makerere University. This year the USAID/Kampala began provided funding support with a match from the IPM CRSP ME to investigate the etiology, epidemiology and integrated management of coffee wilt (*Fusarium xylarioides*).

IPM Constraints Addressed

The primary IPM constraints addressed at the Uganda Site are: 1) poor linkages between research scientists and farmers; 2) A lack of alternatives to multiple applications of chemical pesticides, particularly for important legume crops such as groundnuts and cowpea in Eastern Uganda, but also for important horticultural crops including tomatoes and potatoes; 3) research fragmentation caused by insufficiently integrated research activities of multiple institutions and disciplines; and 4) limited distribution and dissemination of IPM technologies.

In order to address these constraints the Uganda Site implemented a participatory approach to the conduct of IPM research. The initial field PA held with farmers at research sites in Iganga and Kumi Districts in 1995, and now verified by two baseline surveys, identified priority crops and pests. This helped orient research to solving farmer problems – demand driven activities. Subsequent activities including farmer field pest monitoring, farmer open days, and on-farm trials added to or amended pest and disease priorities. For example, farmer field pest monitoring activities indicated that the bean fly (*Ophiomyia* sp) was a critical yield reducing agent that prior to this activity was unrecognized by farmers. A survey of maize pests and diseases indicated that gray leaf spot (*Cercospora zeae-maydis*) was a seasonally important foliar disease and that termites (*Macrotermes*, *Pseudacanthotermes* and *Microtrmes*) were causing significant stand losses. Recently, the groundnut leaf miner (*Aproarema modicella* Deventer) and thrips (*Thrips palmi* Karny, *Frankliniella schultzie* Trybom, *Scirtothrips dorsalis* Hood, and *Caliothrips indicus*) were determined by farmers and scientists respectively, to be important pests on groundnuts. Researcher interactions with farmers also suggested component technologies that have been integrated into trials. Local farmers suggested the interplanting of *Celosia argentia* with sorghum, and the use of cotton in rotation, to reduce the incidence of *Striga*; and, the use of several locally available bio-rational products in post-harvest storage to reduce bruchid damage.

The frequent use of synthetic pesticides on cowpea and groundnuts was first documented during the initial PA and the latter two baseline surveys. On-farm trials have

successfully demonstrated that a combination of cultural practices and three well-timed spray applications can reduce pesticide applications and farmer exposure to pesticides while maintaining yields. Inter-institutional cooperation has resulted in the incorporation of improved germplasm to reduce incidence of major diseases on maize, groundnuts, potatoes and tomatoes. Institutional cooperation has also been facilitated by the use of Makerere University graduate students to conduct field trials. The IPM CRSP, ICIPE, NAARI's Biological Control Unit and Maize Research Team, and Makerere University scientists combined to provide financial and technical support for MU graduate student Ms. Teddy Kauma to rear, release and monitor the introduced parasitoid *Cotesia flavipes*. Scientists from SAARI, MU, and the USA supervise MU graduate student Mr. Robert Opulot's work. Graduate student work on identifying insect pests of cowpea and timing of chemical spray applications has been supported by the Rockefeller Forum and has been integrated into IPM CRSP work on cowpea.

The integration of various disciplines is still a work in progress. Team meetings, where research work plans and results are discussed with a multi-disciplinary audience, provide a useful platform to exchange disciplinary perspectives. Interdisciplinary work has been greatly augmented by the integration of social science assessments of component IPM technologies for priority crops. The inclusion of co-PIs from various disciplines in PA activities, farmer open days and farmer trial assessments has helped expose biological scientists to the importance of including a farmer knowledge perspective into their own work. It has also helped generate demand for social science assessments in order to help insure that trial design and technology development take into consideration farmers' social and economic constraints.

An assessment of IPM CRSP activities indicated a positive impact on knowledge and awareness of IPM and crop specific pest mangement practices among farmers who had participated in project activities. This assessment also indicated that other methods besides on-farm trials are required to reach a broader audience. As a result of this analysis several different dissemination strategies were implemented this year. First, on-farm research trials for cowpea and groundnuts were extended to 10 new farmer groups in Kumi, Pallisa, and Iganga districts. Second, a pilot IPM training program was implemented with 8 extension agents in Iganga district.

Regionalization of IPM CRSP activities has largely been promoted through the participation of co-PIs in regional fora including the All African Crop Science Society, the International Association for Farming Systems Research, the Rockefeller Forum, collaboration with ICIPE, and the Gray Leaf Spot Collaborative Network and Africa Link. Multi-national and institutional collaboration on identifying genetic resistance to gray leaf spot, the number one foliar disease of maize in the US corn belt, is the best example of IPM CRSP Uganda Site activities directly benefiting the USA.

Institution Building

The IPM CRSP Uganda Site has placed a great deal of emphasis on human resource development. Graduate student training at Makerere University has helped facilitate domestic and international institutional collaboration and has contributed to research output. Six Ugandan graduate students have completed or are in the final stages of completing their MS degrees. The CIAT and IITA programs in Uganda have each hired one of these graduates; one has accepted a job with the newly created National Agricultural

Advisory Service; and one is now pursuing a doctoral degree at Makerere. Two Ugandans participated in short-term (2 month) training programs in the United States, at The OSU Agricultural Research and Development Center (OARDC). Dr. Georgina Hakiza, a co-PI Plant Pathologist with CORI worked in the laboratory of Dr. Sally Miller, learning techniques and typing different strains of *Fusarium xylarioides*. Miss Mildred Ochwoh, a Ugandan graduate student, worked in the laboratory of Dr. Sophien Kamoun on the characterization of potato late blight (*Phytophthora infestans*). A unique collaboration this year involved Mr. Stuart Gordon, PhD candidate in the Department of Horticulture and Crop Science at OSU. He spent two months in Uganda co-teaching a graduate Plant Breeding class and conducting research on verification of methods for inoculating maize with gray leaf spot (*Cercospora zeae-maydis*).

There were 13 trips made to the Uganda Site this year by USA based co-PIs. In mid-October, Drs. Warren, Deep and Erbaugh worked with scientists at the Coffee Research Institute to develop a work plan for addressing the Etiology and Epidemiology of Coffee Wilt. Dr. Willson's last trip to Uganda was made at this same time to assist in the implementation of field trials. In early February, Drs. Taylor and Erbaugh went to Uganda to work with social scientists on data collection and analysis. Drs Gebrekidan, Erbaugh, Warren, Hammond, and Pratt attended the annual work plan development meeting in March. Dr. Larry Grossman from Virginia Tech came to Uganda in April to initiate planning for a GIS workshop to be held in Uganda next year. Dr. Greg Luther traveled to Uganda in late May to continue his collaborative effort with Dr. Kyamanywa and graduate/undergraduate students on the identification and biology of beneficial insects on cowpea and groundnuts. Drs. Willson, Taylor, Pratt and Warren provided special lectures to students at Makerere University. Finally, Dr. Erbaugh again returned to Uganda in early September to Chair the Annual Report Preparation Meeting. Drs. Kyamanywa and Hakiza traveled to the USA to participate in the IPM CRSP Annual Conference held at Virginia Tech.

Networking

Networking is facilitated by the functional links between the Site and Deputy Site Coordinators and their respective organizations, and close communication with the Site Chair. These linkages are reinforced by visits made by USA based co-PIs, usually in the company of the Site Chair and Coordinator, to the Director General of NARO, to the Dean Faculty of Agriculture and to Directors of participating research institutes. Preliminary research results are presented by co-PIs at the two annual meetings held in Uganda. Visits by the Site Chair always include update meetings with USAID/Kampala and other USAID sponsored efforts such as IDEA and ACDI/VOCA.

Regional networking is conducted via electronic communication, research collaborations, and participation in professional societies and symposia. Formal research collaborations with ICIPE and the Rockefeller Foundation focus on mutual contributions to graduate student training and advising. Direct communication between Uganda co-PIs and USA co-PIs have resulted in germplasm exchanges with IITA, CIP, ICRISAT, an USDA potato research program, and CIMMYT/Harare. Regional representatives from CIP and ICIPE participated in this year's work plan development meetings. This year Uganda co-PIs and graduate students presented 10 papers at the All African Crop Science Society meetings held in Lagos, Nigeria. Three USA

based co-PIs contributed papers to this conference but were unable to attend. Additionally, Drs. Kyamanywa and Agona participated in the IPM CRSP Annual Conference held in Blacksburg, Virginia.

Research results are also spread through publication. This year there are eight articles that have been published and an additional four that have been submitted.

Selected Research Accomplishments

1. **Cowpea:** Demonstration trials assessing 6 different IPM packages for cowpea were implemented with 10 different farmer groups in Kumi and Pallisa districts. The IPM package (IPM 1) consisting of early planting (at on-set of rains), sole closely spaced cowpea (30 x 20 cm.), and three timed insecticide applications, once at budding, flowering and podding stages, had the highest yield of 791 kg/ha, with a 51% yield gain over farmers' traditional practice. Farmer evaluations of IPM packages indicated their preference for this package.

However, marginal rate of return analysis indicated that IPM 1 ranked third in terms of increased net benefits when cowpea was sold two months after harvest. Two packages that differed only on planting dates, one early (IPM 4) and the other late (IPM 6), included close spacing and sole cropped cowpea but no pesticide applications, had the higher net benefits. In Kumi the highest marginal rate of return was recorded for packages 6 and 4 at (1749%), while in Pallisa the rate of return for these same two packages was (987%). Only IPM 4 had benefits less than total variable costs when cowpea was sold immediately following harvest because prices at this time were low.

It is acknowledged that the results of the economic assessment seemingly contradict findings from the demonstration trials and farmer evaluations. Thus a methodology for gaining a more in depth understanding of farmer rationales for preferring IPM 1, and the use of pesticides will need to be implemented next year.

This second year study verifies that the relationship between thrips (*Megalurothrips sjostedti*) population density and cowpea grain yield loss is linear and negative. However, the economic injury level (EIL) for thrips on cowpea was lowered from 12 to 7 thrips per inflorescence.

The intensity of cowpea pod pests (*Riptortus* spp., *Nezara viridula*, *Acanthomia* spp., *Anoplocnemis* and *Maruca* sp.) infestation in the field directly affects bruchid (*Callosobruchis chinesis*) infestation in storage. Treatments with Ambush CY and Sumithion 50% EC recorded the least damage by pod pests. In plots sprayed with botanicals (tobacco, tagetes and tephrosia) pod damage levels were reduced but were higher than when synthetics were used. Tobacco was the most effective among the botanicals. Botanicals showed moderate effects on control of cowpea bruchid damage levels in storage compared to synthetics with the most effective, again, being tobacco.

Preliminary results indicate that defoliation of cowpea (an indigenous practice for harvesting cowpea leaves) significantly reduced population densities of thrips, pod sucking bugs, and *Maruca* pod larvae, and also significantly increased cowpea grain yields.

Ten new cowpea varieties have been recommended for advanced testing trials. These promising new varieties were selected from 200 and 177 entries in 2000 and 2001. Sources of resistance to various cowpea diseases have been identified and require further evaluation.

2. **Groundnuts:** The monitoring of 3 major new pests/diseases of groundnuts, including thrips (*Thrips palmi* [Karny], *Frankliniella schultzie* [Trybom], *Scirtothrips dorsalis* [Hood], *Caliothrips indicus*), leaf miners (*Aproarema modicella* Deventer) and foot rot (*Sclerotium rolfsii*), in three districts in Eastern Uganda this year indicated differences by district and rainy season for the various pests. Leaf miner incidence and severity was highest in Kumi and lowest in Iganga; and the second rainy season had a higher incidence than the first. Leaf miner infestations are known to be triggered by less rainfall and hotter conditions, which are more associated with Kumi district and the second rainy season. Thrips infestations only varied significantly by location, with greater numbers being found in Soroti than in Kumi. Foot rot incidence also varied by district and season, being highest in Kumi and lowest in Iganga; and was lower during the second rains.

Two seasons data collected on the effect of cultural practices (plant density and planting time) and host resistance on rosette and *Cercospora* leaf spot indicate that high plant density significantly reduced rosette incidence, but had not significant effect on the aphid vector. Contrastingly, close spacing recorded high *Cercospora* severity as opposed to moderate and wide spacing. Early season planting significantly reduced the incidence of rosette and severity of *Cercospora* leaf spots and leaf miner damage. Host resistance significantly reduced the incidence of rosette and *Cercospora* leaf spots. The variety Igola-1, was most resistant to the two diseases and the traditional variety Erudurudu was most susceptible.

Three seasons data have been collected on the effect of different spray schedules on the major pests and diseases of groundnut. The most efficacious method for spraying was to apply 2-3 insecticidal sprays. Leaf miner damage was most severe in plots that received more than three insecticidal sprays.

Three seasons of data collected from the screening experiment indicated that eleven genotypes from ICRISAT and one from Uganda consistently showed resistance to rosette and *Cercospora* leaf spots.

In summary, these finding indicate that integrating host resistance, chemical sprays and planting time and density reduces the need for more frequent use of synthetic pesticides from over eight per season to 2-3, and is more economical than use of only cultural or synthetic pesticides.

3. **Maize:** Establishment of *Cotesia flavipes,* a Braconid parasitoid of the stalk borer *Chilo partellus,* has been demonstrated at release sites in Iganga, Kumi and Soroti with parasitism up to 30% in Kumi. The recovery of *C. flavipes* from non-release sites demonstrates that the parasitoid is colonizing new areas, however, parasitism rates vary according to stemborer species, location and crop.

Farming system characteristics play a major role in the observed epiphytotics of gray leaf spot (*Cercospora zeae-maydis*) in Uganda. The amount of residue infested with *C. zeae-maydis* greater than 40% soil coverage at the time of planting and thereafter may be an important factor increasing maize foliar damage by GLS. Farmer practices such as leaving stover in the field to be planted in maize the following season lead to high GLS disease development. This practice is carried out by 38% and 48% of the farmers in Mubende and Tororo respectively. Continuous cropping with maize coupled with use of susceptible varieties like H614 and H511 also lead to severe GLS epiphytotoics. Our finding that in areas where the disease

pressure is high, the epidemic will be suppressed if resistant varieties are used, lends support to our conclusion that effective management will require varieties with improved host resistance to GLS.

Greater understanding of the epidemiology, varietal susceptibility, and farmers management practices have allowed us to compile a fact sheet concerning GLS for distribution to extension agents, scientists, and professionals in Uganda.

Development of biotechnology techniques through identification of SSR molecular markers are utilized for marker assisted trait selection. The heritability of GLS in breeding materials will enhance the efficiency and efficacy with which susceptible varieties can be converted to resistance. Maize improvement in Uganda is best aided by the identification of new sources of resistance.

The verification of gray leaf spot (*Cercospora zeae-maydis*) inoculation methods study demonstrated that the hypodermic injection of conidial suspension into the whorls of young maize plants at three-leaf growth stage produced substantial gray leaf spot symptoms that was able to show genotypic difference among the progenies tested. Therefore, this is a good technique for screening for resistance to gray leaf spot in young maize plants.

Promising sources of resistance have been identified for GLS, turcicum leaf blight and maize streak virus. About 10 seem to possess multiple disease resistance.

Termites (*Macrotermes*, *Pseudacanthotermes* and *Microtermes*) are increasingly important problem on maize. Using powdered fish bones as bait increased predatory ant activity by 90% and suppressed termite damage by 54% compared to untreated control plots. The production of the fish bone baits is inexpensive, does not require high input technology, and can be prepared locally and applied easily.

Applying baits in shallow furrows led to significantly higher ant nesting compared to surface applications. The superior performance of buried bait is probably related to the availability of suitable nesting sites (inside maize stalks) for ants in the vicinity of protein-rich foods.

4. **Sorghum:** Inter-cropping sorghum with silver leaf desmodium at a ratio of 1:2 reduced *Striga* infestation by 65% compared to sole cropping sorghum. Intercropping sorghum with silver leaf desmodium at a ratio of 2:2, sorghum with *Celosia argentia* at ratio of 2:1 and sorghum with Bambara nut at ratio of 2:1, recorded the highest net benefits.

Seed coating Epuripur, an improved but susceptible variety, and IS8193 sorghum genotypes with 0.1% 2,4-DB reduced *Striga* infestation on sorghum by 86%-90%.

Involving both cowpea and cotton in a five way rotation with sorghum reduced *Striga* emergence by 48.8% compared to continuous sorghum cropping. This observation suggests that two or more trap crops need to be included in the same rotation with sorghum for at least five seasons in order to suppress *Striga* emergence.

5. **Tomato**: For two seasons, tomatoes sprayed with fungicide were less severely infected by late blight (*Phytophthora infestans*) than those that were not sprayed. Examining the effect of management practices indicates that trellising, staking, and mulching resulted in lower, though varying levels of late blight infection. Using dry grass mulch produced the highest yields of tomato fruits. The introduction of 13 new tomato lines from AVRDC demonstrated 90-100%

resistance to bacterial wilt (*Ralstonia solanacearum*) compared to 4 traditional varieties. The use of trellising, yellow thrips traps and *Metarhizium* reduced thrips (*Thrips tabaci* and *Frankliniella* spp.) populations on tomatoes.

Peri-urban smallholder tomato production can be profitable but requires improved yields and quality of produce and improved management of renewable resources (soil fertility) at the farm level. The agricultural support institutions can best assist these small-scale farmers by helping them select seed, providing alternative seed with disease resistance/tolerance and by helping them find alternatives to the frequent use of chemical pesticides.

6. **Potato**: For potatoes grown in Kabale (Southwestern Uganda) a combination of early planting (at the on-set of rains), using resistant varieties, and using a contact fungicide (Mancoseb 80% WP) at moderate levels (3 applications) resulted in lower incidence of late blight (*Phytophthora infestans*), higher yields, and highest rate of economic return. Early planting resulted in lower disease severity than mid-season planting. However, higher yields obtained with mid vs. late season planting are attributed to reduced rainfall rather than disease severity. In general, integrating time of planting into late blight management strategies increases yields and economic return.

The result of a marginal analysis indicate that that it pays the farmer his original investment as well as over 800% rate of return for every extra unit cost of spray for susceptible potato varieties if disease monitoring is used. Also, it pays about 500% rate of return for resistant varieties when the crops are sprayed at 21-day intervals. Spraying potatoes weekly or fortnightly for both the susceptible and the resistant varieties is not only a waste of farmers' meager resources but also is not cost effective. The marginal net benefits are reduced as more spray is administered.

7. **Mould and mycotoxin**: Mould and mycotoxin contamination of maize and groundnuts starts in the field and continues during storage. In maize and groundnut samples obtained from farmers, *Aspergillus*, *Fusarium*, *Penicillium* and *Rhizopus* were the predominant moulds isolated and occurred in both newly harvested and stored samples, with *Aspergillus* showing the highest incidence. Zearalenone levels were found to be above the recommended limits of 1 ppm in both maize and groundnuts while B1 was the predominant aflatoxin.

Storage of maize in polypropylene bags kept the amount of Zearalenone below toxic levels. The majority of farmers (73%) in Iganga were found to store maize in polypropylene bags, however, those storing maize under their verandahs, had high moisture content, mould infection, and mycotoxin levels.

Although farmers in Kumi generally dry and store groundnuts at safe storage moisture content levels, field and home drying practices don't seem to protect the produce against mould infection and mycotoxin production. Serere Red, Igola-1 and Otiira appeared to be the most resistant varieties to mould infection and mycotoxin contamination while Erudurudu is the most susceptible.

8. **IPM training**: Two hundred and seventy-three farmers in Iganga district were exposed to IPM CRSP technologies through demonstration trials implemented by eight extension agents who participated in a six-session, IPM "train-the-trainers' program.

9. **Coffee Wilt**: Studies were conducted at the Coffee Research Institute (CORI) to

determine sources of inoculum for *Fusarium xylarioides*, the causal agent of coffee wilt disease (CWD). These studies established that the optimum inoculum concentration required to incite CWD was in the range of 1300 and 130,000 spores ml^{-1} and concluded that exposure time was less important for pathogen infection. It was also found that *F. xylarioides* spores collected from infected coffee stems and inoculated *in situ* cause CWD, and these together with infected coffee stems could be the avenues through which the pathogen Tentative results indicate that *F. xylarioides* is not seed transmitted.

West Africa Site in Mali

Keith M. Moore, Site Chair, Virginia Tech; Kadiatou Touré Gamby, Site Research Coordinator, Institut d'Economie Rurale; Bouréma Dembélé, Site Administrative Coordinator, Institut d'Economie Rurale

The Collaborative Program

The IPM CRSP research program of the Africa Site in Mali is carried out through collaboration of a multi-disciplinary team of scientists based at five U.S. and four Malian institutions. The four Malian institutions playing a leading role are the agricultural research institution *Institut d'Economie Rurale (IER*), the extension organization *Opération Haute Vallée du Niger (OHVN)*, the toxicology laboratory of the *Central Veterinary Laboratory (LCV)*, and the *Institut Supérieur de Formation et de Recherche Appliqué (ISFRA)* of the *Université de Mali*. The Africa Site in Mali is based at the *IER*. *IER* provides the administrative and research coordination as well as leading scientists for the research activities, contributing expertise in entomology, plant pathology, and weed science. IPM CRSP collaboration constitutes a key element in *IER*'s long-term plan as defined within the framework of World Bank financing.

The IPM CRSP Project in Mali is supervised by two coordinators. Dr. Kadiatou Touré Gamby, Head of Fruit and Vegetables based in Sotuba, ensures the scientific coordination of the project, and Dr. Bouréma Dembélé, Scientific Director for IER and Head of the Weed Science Program, ensures the administrative coordination of the project. The coordination of IPM CRSP activities at the research station of Cinzana (CRRA/Niono) is carried out by Mr. Mohamed N'diaye, Entomologist for Millet and Sorghum, and Mr. Sériba Katilé, Plant Pathologist for Millet and Legumes. The IPM CRSP collaboration with *OHVN* is ensured by Mr. Issa Sidibé, Section Head for Research and Development Linkages. *OHVN* works with the private sector in production and marketing of export horticultural crops, including green beans exported to France and hibiscus exported to Senegal, Germany, and the United States. Pesticide residue evaluation activity for exportable products (green beans, tomatoes) financed by the USAID Mission in Bamako is conducted in collaboration Toxicology Laboratory of *LCV* under the direction of Dr. Halimatou Koné Traoré. *LCV* is taking the lead in developing a Quality Assurance System for horticultural produce. *ISFRA* provides training for master's students working on IPM CRSP project activities.

In the United States, five institutions contribute to the collaborative research program: *Purdue University*, contributing expertise in vegetable IPM (Dr. Rick Foster); *North Carolina Agricultural and Technical University*, contributing expertise in

economics of small-scale producers, including women's horticulture and export markets (Dr. Anthony Yeboah); *Montana State University*, contributing expertise in post-harvest assessment, natural pest control products, and technology transfer (Dr. Florence Dunkel); and *Virginia Tech*, contributing expertise in weed science, pesticide residue analysis, and quality assurance (Dr. James Westwood, Dr. Don Mullins, Jean Cobb and Patricia Hipkins). *Virginia Tech* also provides leadership in the person of the Site Chair (Dr. Keith M. Moore). The *University of California-Davis* will be contributing expertise on viral diseases in tomatoes in Year 9 (Dr. Robert Gilbertson).

In IPM CRSP Year 8, the third year of Phase II, the Mali Site has consisted of participatory on-farm research on IPM technologies for the management of disease and insect pests of the two most important peri-urban horticultural export crops (green beans and hibiscus) and the most important domestic crop, tomato. In the first years of Phase II research on horticultural export crop pest management, IPM components were developed independently to provide the basis for subsequent combination into packages that address different pest problems simultaneously. This research is complemented by on-station research on biological control of the key insect pests of hibiscus, and innovative approaches to management of *Striga* parasitic weed on millet and sorghum, the principal cereal crops of Mali. The second stage of Phase II research focuses on the testing of pest management techniques as integrated packages, and the third stage involves disseminating farmer-tested IPM packages for each horticulture crop in the program. A participatory assessment of IPM technologies for green beans provided increased focus for the transition to the second and third stages of Phase II.

In addition, these research efforts serve to support the development of a system to reduce pesticide residues on agricultural products through the new *Environmental Quality Laboratory (EQL)* of the *Central Veterinary Laboratory (LCV)*. Rational use of pest control measures may include synthetic pesticides. Consequently, pesticide residue analysis allows for the provision of information on both the current performance and potential improvements of the system. Combined with on-farm research, pesticide residue analysis aids in the development of IPM technologies for quality produce verified to meet international food safety standards and residue levels, and insure the safety of farmers using pesticides.

Technology Transfer

Since its creation, the IPM CRSP has worked with the *OHVN*, which has as a principal objective ensuring food security and the diversification of the farmer incomes. The *OHVN*'s zone of intervention is along the Niger River, a region of market-garden production. Through its Agro Business unit, the *OHVN* ensures the connection between producers and wholesalers, including exporters such as *Flex Mali* and *Mali Première*, both exporters of green beans. In the last few years green beans have become one of the principal export crops towards Europe and this has allowed many small farmers to engage in export agriculture. In *OHVN* zones, green bean production was 124 tons in 2000 with 95 % destined for export and 5% sold on the local market.

The IPM CRSP has collaborated with FAP in the development of didactic materials designed for extension agents and farmers through technical and financial support. For improved diffusion of the technologies developed, the IPM CRSP also collaborates

with *PRONAF Mali* (*Project Niébé Africa*), financed by the *International Fund for Agricultural Development (FIDA)* using the Farmer Field School concept. During this past year farmer field schools have been conducted with farmers in the villages of Dialakoroba, Dienfing, Koren, Kondialan, and Sanambélé.

The program carried out through the IPM CRSP focuses on the major thrusts of *IER*'s ten-year strategic plan. This work plan is re-examined annually during meetings of the *Regional Users Committee (CRU)* and the *Regional Technical Committee (CTR*). At the end of each season, research results are reviewed and plans for the subsequent year are discussed with the farmers.

Collaboration has increased in the dissemination/regionalization of IPM CRSP Mali Site Phase I results. A poster series was developed in collaboration with the *US Peace Corps-Mali* (Ag Sector) and *World Vision-Mali* (Bla Region) as a means of transferring IPM technologies to farmers. Assessment methods for one of the dissemination/regionalization plans has been developed and preliminary testing conducted. It is expected that up to 6,800 small farmers will have access to IPM CRSP research results from the combined Peace Corps and World Vision outreach programs provided with these IPM CRSP training materials. The SANREM CRSP is transferring an adapted version of a striga management practice at its West Africa Site in Mali.

IPM Constraints Researched

At the beginning of the IPM CRSP Phase II, a hundred green bean farmers were interviewed and agreed that insects and diseases constitute the primary constraints for green bean production from seeding to harvest. Harvest losses are very high, on the order of 4000 kilograms per hectare, a loss of 160,000 Francs CFA. In addition to the loss in weight, there is also the decline in bean quality caused by insects (such as borers) because the presence of a single damaged pod can result in the rejection of an entire carton destined for export. The principal pest problems for green beans during the past few years have been thrips, whitefly (*Bemisia tabaci*), pod borers, and soil born diseases.

At this mid-point of Phase II, Farmer Field School collaborators and non-collaborators in each of the five targeted villages were asked to participate in a Participatory Assessment (PA) of green bean production practices in their villages. Many changes have occurred since the early years of producing green beans. Early crop protection practices involving use of a "white powder" (DTT) applied with perforated nescafé tins have been replaced by the introduction of Décis and Sumicombi. These products are now gradually being replaced by the neem leaf extracts, colored traps and tobacco powder. Diseases are being managed by the incorporation of cabbage residues into the seedbed. Weeds are reduced through burning grass stubble and seeds before sowing. The mode of pesticide application has also evolved. Nescafé tins have been replaced by manual sprayers and ULV apparatuses for pesticide application.

Seedbed fertilization that had consisted of poorly decomposed manure to which one added a cotton fertilizer complex has been replaced by well-decomposed manure to which one adds the cotton fertilizer complex and urea 15 days later. Standardization of seedbed dimensions (2 meter by 1 meter) has facilitated the execution of the plot maintenance.

The PA also demonstrated that the role of the export purchasing agents has become more

important for green bean production. At the start, their role was limited to providing seeds and some times plant protection products, and the purchase of harvests. Gradually, these agents have widened their range of intervention. Currently, they not only provide the seeds and Decis, but also the watering-cans, transport, and specific instructions concerning product quality and the timing of the harvest. The role of the economic operators is key in the development of the production system. If they don't like the quality of the harvest, they won't buy it. Some of them have adopted researcher recommendations, but working relations between researchers and purchasing agents have yet to develop.

Despite positive results obtained with the introduction of improved technologies, certain problems persist. Among the most frequently cited constraints identified during the Participatory Assessment were: (1) the lowering of the water table of the wells which decreases the potential for increasing production; (2) attacks of birds which damage pods causing significant losses of production; (3) the problem of acquisition of certain inputs, such as plastic mulching covers and petroleum jelly; and (4) delay in the payment of the producers.

The impact of pest management tactics on the quality of horticultural crops grown for domestic consumption and export has been difficult to assess. In order to rectify this situation, the *Environmental Quality Laboratory (EQL)* of the *Laboratoire Central Vétérinaire* has been targeted to monitor pesticide residues and thereby provide quality assurance for consumers in Mali and in Europe. This work has involved the development of standardized methods and processes for management decision-making, equipment maintenance, and supplies procurement. Skills in sampling and analysis for pesticide residues are also being developed.

Constraints for two other important peri-urban horticultural crops (tomato and hibiscus) have been diagnosed. For tomatoes, the major constraints identified have been diseases attacking the plants and the fruits: viruses, *fusarium*, soil born diseases, fungal and bacterial diseases due to *Pseudomonas*, and insects, such as white flies (*Aleurodes*), virus transmitting insects, green fleas (particularly in nurseries), and *Heliothis armigera* whose larva attack the leaves, buds and flowers. Crickets and grasshoppers are also very dangerous in the nurseries, leading to delays in replanting.

Improvements in the production system for hibiscus have been confronted with agronomic problems (fertility and varieties), insects such as *Nisotra*, and diseases due to nematode galls. The latter damage the leaves, leading to late vegetative development and significant petal losses.

The parasitic weed *Striga* remains one of the major constraints to cereal production in sub-Saharan Africa. Research into new approaches for limiting *Striga* damage to sorghum and millet crops in Mali has continued into a second year. This work, initiated in 1999, is testing the hypothesis that small quantities of herbicides absorbed into crop seeds can serve as a deterrent to early parasitic attachments of *Striga*. A critical component of this is the identification of a herbicide that is safe for the crop, yet inhibitory to growth of the parasite.

Institution Building

The human resource development strategy prepared for the Mali Site is long term in perspective, assuring a breadth of skills and capacities available for IPM research into the

future. This multi-faceted program depends on the *University of Mali* for the training of two master's degree students in weed science, and economics/sociology. Alfousseini Ba is working on his masters degree in socio-economics at *ISFRA* under the direction of Sociologist, Dr. Denis Dougnan, in collaboration with Mrs. Penda Sissoko Sow, Economist, CRRA/Sotuba, and Dr. Keith M. Moore, Sociologist, OIRD/Virginia Tech. Mountaga Kenyatao is completing his masters degree at *ISFRA* under the direction of Dr. Bouréma Dembélé, Weed Scientists IER, and Dr. Hess, pathologist, ICRISAT. Dr. Dembélé also directed the research of Adama Wague on chemical treatment of striga in millet and sorghum, who obtained a diploma of Engineer at *Institut Polytechnique Rural de Formation et de la Recherché Appliqué (IPR/IFRA)*. Two U.S. students are expected to start training in economics and entomology at *North Carolina A&T* and *Montana State University*, respectively.

The Farmer Field School Program involved the training of 5 IER technicians and 5 OHVN technicians in addition to the targeted 25 green bean producers. A Malian gender specialist participated in a short-term training program in the statistical analysis of social scientific data and a Malian weed scientist received short-term training this year. For the second year in a row, a month long training for two scientists of the *EQL* was conducted at the Pesticide Residue Laboratory. All short term training in the US was conducted at Virginia Tech.

Institutional strengthening is reinforced by frequent opportunities for one-on-one collaboration in the planning and conduct of research activities. Ten trips were made to Mali by U.S. scientists to collaborate with *IER* and *LCV* scientists and *OHVN* collaborators on issues ranging from biological control of tomato viruses (Drs. Gilbertson and Moore) and hibiscus insect pests (Dr. Foster), assessment of weeds in peri-urban horticulture (Dr. Westwood), drafting entomology papers (Dr. Florence Dunkel), to toxicology laboratory development (Dr. Mullins and Cobb), quality control assurance and pesticide usage and application (Drs. Moore and Hipkins). On the Malian side, six visits were made to the U.S. Dr. Gamby and Issa Sidibe visited the U.S. for the annual planning meeting and discussions concerning the development of a pesticide safety program for horticultural farmers, Haoua Sissoko and Bouréma Dembélé worked on gender data analysis and weed science, respectively, and Dr. Traoré and Mrs. Dem participated in training at the Pesticide Residue Laboratory at *Virginia Tech*.

The Malian Government supports *IER's* IPM Program by paying salaries of the researchers and technicians, and supplying equipment and supplies (vehicles, offices, laboratories and experimental fields, etc.). Additional support for institution building has come from the IPM CRSP in the form of two computers, for the socio-economic and weed programs at the CRRA/Sotuba research station of *IER*. In addition to this material support, the IPM CRSP has made an important contribution to research in Mali by establishing and maintaining a strong multi-institutional and pluri-disciplinary team in collaboration with farmer associations.

Networking

The core mechanism for in-country diffusion of research results depends on the relationship between *IER* and *OHVN* in the peri-urban horticultural regions. This relationship is built on the work of *IER/OHVN* liaison officer, Issa Sidibe. The network extends from field agents in the peri-urban horticultural regions encountered frequently

in the field (by Pat Hipkins, John Caldwell, Mme Gamby, and Moussa N'diaye). Dr. Moore has established contact with *ISFRA* Sociologist Dr. Denis Dougnon for the preparation of Alfousseini Ba's thesis. Dr. Dunkel is developing collaborative relations with the *US Peace Corps-Mali* (Ag Sector) and *World Vision-Mali* (Bla Region) as a means for transferring Phase I IPM CRSP technologies to farmers

IPM CRSP research results have been presented at the Regional Technical Committee (CTR) meeting at Sotuba (May 2001), at the Regional Users Committee (CRU) meeting at Sotuba (March 2001) and to the IER Program Committee (June 2001). Site Coordinator Mme Gamby was invited to participate in the Regional Training Workshop on Integrated Phytosanitary Management and Pesticides held in Segou, Mali from 6 through 10 November 2000. This seminar was organized by the NGO, Africare, and involved USAID personnel as well as plant protection agents across Mali. Research results were also demonstrated during the IER Field Day at Cinzana Agricultural Research Center in October 2000.

Pesticide safety education efforts included curriculum planning, a needs assessment, and delivery of sample/test lessons to a group of 18 people who attended a January 2001 training session at CRRA/Sotuba. Topics presented at the training session included an overview of pesticide safety, small group workshops, and a demonstration of pesticide handling and exposure. In addition, the participants assessed lesson content and presentation styles with regard to what modifications, if any, should be made before using them to instruct Malian farmers. Workshop participants included representatives from the *Institut d'Economie Rurale's* CRRA/Sotuba, the *Office de la Haute Vallée du Niger* (OHVN), and *Direction Générale de la Réglementation et du Contrôle* (DGRC). An informal needs assessment was also conducted at one village after demonstrating how flip charts could be used to teach PSE. Village farmers expressed an interest in learning more about pesticide safety using flip charts as teaching aids.

Regional networking is built around several foci. Dr. Moore, Dr. Gebrekidan, and Dr. Ramaswamy met with Amadou Diarra of the *Institut du Sahel (INSAH)*) to discuss farmer and vendor training in safe pesticide use and IPM technology for horticultural export production. Diarra is the *CILSS* liaison for harmonization of pesticide use. Dr. Traoré has initiated contacts with Dr. Abdoulaye Niassy, *DPV/Sénégal* and the USAID/Washington-funded Biopesticide Development Project as well as participating in laboratory training in Morocco and Hungary. Through contacts with the USAID mission-funded *Centre des Agro-Entreprises (CAE)*, the *EQL* is also extending its network. Dr. Traoré has continued collaboration with Dr. Ardjouma Dembélé of *LABECO* in Ivory Coast, particularly in terms of developing improved supply sources for laboratory chemicals.

Research Accomplishments

The most abundant insects on green beans before flowering were whiteflies (*Bemisia tabaci*). They infest the plants from the seedling stage until flowering. Thrips infest the plants when flowers appear, reaching their peak population densities at about 50% flowering. Untreated green beans can be heavily infested by thrips, reaching densities of 19 individuals per flower. Neem extract combined with colored traps (IPM) reduced the infestation of thrips as much or more than the chemical pesticide applied by the farmer. In each village, the IPM plots had thrips

densities that were comparable to the chemical treated plots, but both were significantly lower than the untreated control. At harvest, IPM plots had significantly lower percentages of pods with insect damage than the plots treated with chemical insecticides in each of the three villages. In two villages, the chemically treated plots had fewer damaged pods than the untreated control. In addition to the reduction of the infestations of whiteflies and thrips, the IPM plots produced yields similar to the plots treated with chemical pesticides in each of the three villages. The extracts of neem associated with the traps (blue and yellow) protect green beans as effectively as the chemical Decis (deltamethrin) traditionally used by the farmers.

- The IPM treatment (neem extract + colored traps) was more profitable in the growing of green beans than use of chemical pesticides. The cost of the IPM treatments is estimated at 15,780 F CFA ($22.29) / ha with an additional net profit of 3,704,000 F CFA ($5224.26)/ ha.

Climatic conditions this year were not good for the appearance of seedling wilt disease in the periurban area of Bamako. All disease trials on vegetables had the same results. It is impossible to evaluate the effectiveness of the IPM practices on disease this year but yield results at Koren showed significant differences. Well-decomposed compost gave the best results and all the treatments were better than the control. Plots with clear or black plastic had yields comparable to the farmers' compost, although significantly lower than the well-decomposed compost. Plots treated with *Lonchocarpus* had yields similar to the control. In Sanambélé, there were no significant differences in yields.

The IPM technology package consisted of seed treatment with Apron, weekly applications of neem extracts beginning at the button stage, use of well decomposed compost, soil solarization, and blue and yellow sticky traps to capture thrips and whiteflies. This package was compared with the farmer practice, which varied by farmer but usually relied on several applications of deltamethrin to control insects. The IPM package resulted in significantly lower whitefly populations in 2 of 3 villages and significantly lower or similar thrips populations in 4 of 5 villages. Yields were significantly higher in the IPM plots in 4 of 5 villages, with no differences detected in the other village. The number of exportable pods was higher in the IPM plots in all 5 villages, with the increase being statistically significant in 2 villages.

- Field observations lead us to believe that the anti-feedant properties of the neem solution are more important than the insecticidal properties in crop protection.

The flea beetles in the genus *Nisotra* are the most serious pests of hibiscus. The adults perforate the leaves and feed on the capsules and the larvae attack the roots and make entry holes that allow contamination by fungi. Currently, there are no effective methods for control of *Nisotra* except the use of chemical insecticides such as diazinon, malathion, carbaryl, deltamethrin, and endosulfan. Because the flowers are the plant part that is consumed, farmers want to find methods of control that will not result in chemical residues, and that are less expensive. The IPM treatment involved weekly applications of neem extract and was compared against 3 scheduled applications of deltamethrin and against the farmers' practices. The IPM method resulted in an 8% increase in profits from grain and a 9% increase in profits from flowers compared to the farmers' practices. Three scheduled applications of deltamethrin increased profits by 34 and 47%, respectively,

for grain and flowers. Four hibiscus varieties were compared for their attraction to *Nisotra* and other insect pests. The Senegalese variety consistently had the fewest number of *Nisotra* present, usually had the fewest number of other insects, and had significantly higher grain yields than the other varieties. The yield of flowers was slightly reduced in the Senegalese variety when compared to the Vimto and Thailand II varieties. Vimto had high insect densities and damage, but also produced the highest yields, demonstrating that it has a degree of tolerance to insect feeding damage.

A combination of IPM techniques for managing pests of tomatoes was tested on 4 farms in each of 6 villages. The techniques used included seed treatment, soil sterilization with hot water and black plastic, the use of neem extracts as foliar insecticides, and a new tomato variety. In the majority of villages, the IPM treatment resulted in fewer insect pests, less insect damage to fruit, and higher yields when compared to the farmer standard. The Petomech variety also tended to have slightly lower insect densities, lower amounts of damage, and higher yields than the Roma variety. The Petomech variety produces firmer fruit that have a longer storage life than Roma. The combination of the new variety and the IPM practices provides growers with the opportunity to increase their productivity and profits.

- Research has identified potash and leaf extracts as an effective treatment for controlling *Cyperus rotundus* in green beans prior to the growing season.

During the marketing year 2000-2001, IPM CRSP researchers tested methods of weed control for protection of green bean, tomato, and hibiscus. The objective of the study was to increase production of these crops by minimizing the incidence of weeds, especially *Cyperus rotundus*, using solutions based on plants extracts. Treatment solutions consisted of 200g of potash (derived from ash of *Kaya senegalensis* wood) plus water extracts of eucalyptus or neem (*Azadirachta indica*) leaves. This formulation was applied as a soil drench to *C. rotundus* bulbs in a pot experiment and in field plots. The results indicate that three applications of the formulation with neem or eucalyptus extract resulted in the death of more than 94% of *C. rotundus* seedlings. Leaf extracts alone were less effective than the potash-containing formulations.

During the 2000-2001 growing season, a survey of Malian green bean producers in the OHVN eastern zone was conducted to understand the gendered conditions shaping the division of labor, decision making, information sources and use of IPM technologies. The sample draws on three groups of producers, male collaborators, and both male and female non-collaborators in the IPM CRSP farmer field trials and Farmer Field Schools in three villages. The division of labor and decision-making in men's and women's gardens demonstrates a certain symbiosis as decision-making seems to be a function of labor contribution. While men's labor is quite stable across all production activities, women's labor varies both on their own plots and on those of their husbands. Ultimately, however, the green bean exporter appears to be the driving force for many on-farm decisions. All green bean producers use insecticides for pest management, three quarters of them spraying 2 to 3 times a season. Decis, supplied by the exporters, is the most common product, although some have begun using neem leave extract in a soap solution. The majority of producers, collaborators and non-collaborators, men and women want to use more pesticides in order to protect their crops.

IPM CRSP interventions were evaluated through a Participatory Assessment from both a bio-physical and a social perspective. Given the complexity of factors influencing agricultural production, this multidisciplinary research activity triangulated on the factors influencing farmer green bean production techniques and the impact of IPM CRSP technologies introduced into targeted villages. In comparing changes in production practices since the introduction of green beans some 20 years ago in each of the targeted villages, both collaborating and non-collaborating farmers have made significant improvements in production. The IPM field trials and Farmer Field Schools, introduced by the IPM CRSP in the past few years have had further positive impact on production practices. IPM technologies such as neem leaf extract, colored plastic flags, and cabbage residues have been found by collaborating farmers to be quite effective in protecting their green beans. They are beginning to adopt these practices in their own fields, and non-collaborating farmers are also paying close attention to these improved practices (some have already adopted a few of these practices).

The EQL is prepared to analyze green bean and hibiscus samples for three of the synthetic pesticides commonly used in IER field trials. The percent recovery of fortified green beans was 93 ± 9% (fenitrothion, 1.0 ppm); 93 ± 8% (fenvalerate, 2.0 ppm), 88 ± 1% (deltamethrin, 5.0 ppm). The percent recovery of fortified hibiscus was 207 ± 13% (fenitrothion, 1.0 ppm), 166 ± 24% (fenvalerate, 2.0 ppm), and 38 ± 2% (deltamethrin, 5.0 ppm). The high percent recovery values of the fortified hibiscus samples was thought to be due to what are commonly referred to as ‘matrix effects’ of the pesticide/matrix on the gas chromatograph. Additional work needs to be conducted to resolve this problem.

Pesticide safety education lessons developed for use in the U.S. are being adapted for use in Mali. Some of the changes reflect cultural considerations and adaptation to traditional farming methods in Mali, while others take into account the personal protective clothing that is available in Mali and appropriate in a hotter climate. Illustrated pesticide safety materials will be translated from English to French and possibly into Bambara (pending additional funding) for use by village-based trainers when instructing farmers at the village level. These lessons and the development of other teaching aids are being pursued as a result of the strong, positive response to the pesticide safety lessons presented in January 2001 to a test group of individuals from various agencies working with farmers and periurban production agriculture.

Formulated pesticides purchased during a survey of pesticide vendors were analyzed on a GC/MS to verify the identity and purity of the active ingredient in each of the formulations. The pesticides (trade names indicated in parentheses) tested included diazinon (Basedin), cypermethrin + methamidophos (Cyperfos), deltamethrin (Decis and K-Othrine), chlorpyrifos (Dursban), endosulfan (Endosulfan), and carbofuran (Furadan). The identity and purity of the formulations were verified by gas chromatography/mass selective detector (GC/MS) analysis. In one case, there was evidence of contamination of the product with other pesticides and this issue was brought to the attention of the U. S. manufacturer who was responsible for the quality control of the repackager.

Research into new approaches for limiting *Striga* damage to sorghum and millet crops in Mali, which was initiated in 1999, is testing the hypothesis that small quantities of

herbicides absorbed into crops seeds can serve as a deterrent to early parasitic attachments of *Striga*. A critical component of this is the identification of a herbicide that is safe for the crop, yet inhibitory to growth of the parasite. This report presents results from the 2000 field season, in which five herbicides were examined, and a simple application of dicamba to millet seeds was found to reduce the number and dry wt of *Striga* plants attacking the crop. Other herbicides of the auxin mimic class appeared to offer some early protection against parasitism as well, but problems with toxicity to crops remain to be resolved. Weather difference between the first and second year of trials affected levels of *Striga* parasitism, and a third year of trials is underway to resolve contradictions. At the same time, promising results with use of 2,4-DB on sorghum is being confirmed in field and pot studies using additional herbicide rates and crop varieties. In addition to this work, significant progress has been made in a laboratory-based study to identify the general mechanism of resistance in sorghum varieties. Sorghum varieties with enhanced resistance to *Striga* are being widely adopted by farmers, and further breeding effort by Malian cooperators will be aided by an understanding of *Striga* resistance.

The potential for low-level herbicide use to reduce crop losses by *Striga* has been demonstrated. In addition to the previous promising results with sorghum, data now suggests that millet may also benefit from this approach.

The capacity for the weed science team at Sotuba to study direct host-parasite interactions has been improved, along with encouraging results from tests with *Striga*-resistant sorghum.

LATIN AMERICAN REGION

Central America Site in Guatemala and Honduras

Glenn Sullivan, Site Chair, Purdue University; Guillermo Sanchez, Universidad de Valle de Guatemala, Guatemala Site Coordinator; and Stephen C. Weller, Co-PI, Purdue University

Description of the Collaborative Program

The IPM CRSP Central American Site had an exceptionally productive program agenda in Year Eight. The site operates through an active site committee structure, with Guatemala as the prime site for Central America. Dr. Guillermo Sánchez, Head of the Department of Agricultural Sciences and Forestry at the Universidad of del Valle, serves as the regional site coordinator for Central America. The Regional Site Committee is comprised of Dr. Sánchez and Jorge Sandoval (UVG), Ing. Luis Calderón, Danilo Dardón, (ICTA), Juan Enrique Leal (Soluciones Analíticas), Luis Alvarez (ARF/AGEXPRONT), Jorge Mario Santos (MAGA), Luis Caniz (APHIS-IS), Linda Asturias (ESTUDIO 1360), and Maria Mercedes Doyle (ZAMORANO). The U.S. researchers that collaborate with the regional site committee and provide research support, technical support, and program coordination include: Drs. Glenn H. Sullivan, U.S. Site Chair; Stephen C. Weller; C. Richard Edwards; and Ray Martyn (Purdue University); and Sarah Hamilton (Adjunct Professor-Virginia Tech). The overall Central American site activities in Year Eight were funded through U.S. IPM CRSP under subcontract with Virginia Tech, and grant

funds generated from the Government of Guatemala (GOG) and ARF/AGEXPRONT. Grant proposals to APHIS, FAO, FAS / Ministry of Agriculture/Honduras, and the Government of Guatemala were developed in Year Eight for IPM CRSP research activities in Year Eight. Preliminary research agendas and budgets for the Central America Site are established during the annual Technical Committee Meetings. These broad research agendas are then presented to the Site Committee for review, discussion, and prioritization of specific research activities for the year following the participatory format of the IPM CRSP. The Site Committee meets monthly to discuss research progress and make consensus decisions on any revisions. Each collaborator and/or collaborating institution has the opportunity throughout the year to request revisions in previously approved research agendas and budgets. Such revisions require Site Committee consensus.

Substantive discussions were carried forward with Nicaragua and the Ministry of Agriculture in Honduras for the purpose of establishing MOU's in these countries during Year Eight. The MOU with Honduras was finalized and will be operative in Year Nine. ZAMORANO (Honduras) was the principal regional collaborating institution outside Guatemala in Year Eight. FHIA in Honduras will assume a substantive research role with IPM CRSP in Year Nine.

In Guatemala, APHIS and ARF/AGEXPRONT continued to provide strong collaborations in the development of IPM / ICM strategies for reducing pesticide use increasing product quality, and improving the performances for achieving safer food supplies in the NTAE sector. APHIS-IS and MAGA (Ministry of Agriculture, Guatemala) continued to provide collaborative leadership in the development and institutionalization of preinspection programs in Guatemala. MAGA proceeded to revise their domestic development programs in Guatemala commensurate with IPM CRSP program priorities, including community level transfers of IPM CRSP developed production strategies and protocols in the NTAE sector. GOG grants to the IPM CRSP researchers at Universidad del Valle and AGEXPRONT provided funds for community level research transfer activities and training, including field demonstrations. ICTA and UVG have collaborated in testing and revising IPM CRSP production strategies for improved pest management in snow peas (leaf miner), tomatoes (white fly), broccoli (*Plutella xylostella*), and papaya (papaya ringspot potyvirus). ESTUDIO 1360, in collaboration with Dr. Sarah Hamilton contributed substantively to research activities that evaluated the socioeconomic impacts of NTAE production at the community and household levels.

IPM Constraints Addressed

Institutional policies

Science-based production and preinspection policies that lead to reduced pesticide usage and decreased product rejections at U.S. ports-of-entry continue to be the major focus for resolving some of the more important institutional constraints in Central America. In Guatemala, MAGA endorsed these efforts in Year Eight through programs and national policies that encourage substantive adoption at the national level. Private sector institutions have become increasingly supportive through the leadership of Luis Alvarez of AGEXPRONT. GOG initiatives to revise policies commensurate with the demands of a more competitive marketplace in the NTAE sector are now receiving serious consideration.

The need for continuity and enforcement of public and private sector policies such as credit availability at the producer level continues to influence NTAE development in Central America, including the implementation and institutionalization of performance-proven IPM/ICM production practices and certified preinspection programs. In Guatemala, the GOG assumed a more proactive role in Year Eight, and the USAID Mission in Guatemala committed funding for microenterprise financing. AGEXPRONT and ICTA, in collaboration with the IPM CRSP, have continued to play a central role in developing serious efforts to develop more proactive production and post-harvest policies that serve to enhance performance in the NTAE sector.

Technology Transfers

The IPM CRSP made significant progress in transferring biorational IPM/ICM technology to NTAE producers and field technicians in Year Eight. However, many small independent NTAE producers still rely too heavily on chemical control practices and unregistered pesticides for insect and disease control. This constraint is gradually being overcome as more IPM CRSP approved pest management information is transferred through grower workshops, technician seminars, and field demonstrations. These technology transfer and field demonstration activities will be enhanced as the GOG accelerates program initiatives in preinspection and grower certification. Over 75 field technicians and 950 NTAE growers received IPM CRSP approved ICM information and training in Year Seven with follow-up and program expansion in Year Eight. ICTA, AGEXPRONT, and PIPAA (Integrated Program for Protection of Environment and Agriculture, GOG) played important roles in these training and technology transfers.

Research Capacity

We now have a "critical mass" of trained field technicians who are capable of addressing pest management problems using applied science-based protocols and approved IPM/ICM practices developed and transferred by the IPM CRSP. AGEXPRONT and ICTA, in collaboration with IPM CRSP researchers, have played an important role in achieving these results. The GOG and ARF committed over $266,000 in matching funds for IPM CRSP research in Year Eight. In Honduras, the Ministry of Agriculture has confirmed its interest to follow the science-based pest management models developed by the IPM CRSP in Guatemala. The Ministry of Agriculture and FAS have agreed to fund a $100,000 research initiative in Year Nine titled "Identification, distribution and epidemiology of plant virus pathogens that threaten pepper / tomato and cucurbit production in Honduras and Guatemala". This research project will be directed by Dr. Ray Martyn (Purdue) and Dr. M. Doyle (Zamorano), in collaboration with Drs. D. Krigsvold (FHIA), G. Sánchez (Site Coordinator), S. Weller (Purdue) and R. Edwards (Purdue).

The IPM CRSP capacity in socio-economic research activities was strengthened in Year Eight through the leadership of Dr. Sarah Hamilton and her collaborators at ESTUDIO 1360. Quantitative assessments of socio-economic benefits in NTAE producer households provided excellent documentation needed for strengthening the policy and program commitments from the GOG, AGEXPRONT, and other private sector collaborators. Over two-thirds of the NTAE households surveyed in Year Eight reported that they had improved their quality of life since 1980, including: housing, health care, education, and nutrition. Seventy-two percent

of the NTAE households surveyed indicated that they had used profits from NTAE production for the education of their children. These findings clearly helped the GOG make positive determinations in providing nearly $1 million USD to support the development of the first grower-based supply consolidation and preinspection center in the NTAE sector. The IPM CRSP will play an instrumental role in training and technology transfer as these preinspection centers are developed.

Research collaborations were strengthened with the U. of Georgia, AGEXPRONT, and APHIS in helping resolve the ringspot potyvirus problem in papaya. This coupled with the IPM CRSP/APHIS supporting documentation to achieve clearance for papaya into U.S. ports-of-entry provides the basis for significant NTAE trade expansion in the years ahead. Central America has the capacity to be very competitive in Eastern United States markets for quality papaya.

Institution Building

The Government of Guatemala, through MAGA and ICTA, continued to support the IPM CRSP's overall objectives for strengthening scientific capacity and market-focused planning in the NTAE sector. These institutional linkages continue to be among the most important factors in moving the IPM CRSP research and development agenda forward in Central America. The continued GOG commitment provides clear evidence of the IPM CRSP's role in institution building in Central America. Institutional collaborations with FAS, APHIS, FAO have been critically important in helping develop additional program funding and capacity for the IPM CRSP. The USAID Mission's commitment to microenterprise financing in Guatemala in Year Eight serves as a cornerstone for the institutionalization of greater access to credit among small NTAE producers. Credit availability at the producer level has been a major constraint to NTAE expansion and the implementation of biorational production programs in years past.

A USDA/ FAS program review of programs in Guatemala during Year Eight concluded that the IPM CRSP was among the premier entities actively engaged in strengthening institutional alliances and developing sustainable NTAE programs in Guatemala. FAS visits to IPM CRSP sites provided solid evidence of the impact the IPM CRSP is having in reducing reliance on chemical pest management methods and institutionalizing sustainable, biorational pest management strategies.

In Honduras, through the Ministry of Agriculture and in collaboration with Zamorano and FHIA, institutional relationships and research capacity were strengthened with the finalization of an MOU between the IPM CRSP and the GOH, and the subsequent finalization of a $100,000 USD research grant (FAS/GOH) to strengthen research collaborations in resolving the disease problems associated with virus pathogens in NTAE crops. IPM CRSP research agendas were presented to the Ministry of Agriculture for funding in Year Eight. These activities were given approval, and the Ministry of Agriculture signed a MOU with the IPM CRSP Management Entity.

The IPM CRSP in Central America continues to place high priority on strengthening the institutional capacity of collaborators and collaborating institutions. IPM CRSP scientists in the United States have given high priority to strengthening institutional capacity in research, technology transfer, and program implementation.

Student Training

Jim Julian, a U.S. citizen, is working on his Ph.D. under the direction of Dr. Glenn H. Sullivan at Purdue University. His research and training focuses on the impact of non-economic constraints to trade in the NTAE sector of Central America, including food safety and regulatory compliance issues. He will complete his degree in Summer 2002.

Carlos Mayen, a native Guatemalan, completed a summer internship at Purdue University in the 1999 summer term, and now is working on his Master's Degree under Dr. Stephen C. Weller in the Horticulture Department at Purdue University. His research and training is in biorational pest management strategies for Central America NTAE crops. He will finish his degree in May 2003.

Carlos Ludéna, a native Ecuadoran who became associated with the IPM CRSP through his training at Zamorano in Honduras, is completing his Master's Degree in the Agricultural Economics Department under the direction of Drs. Kevin McNamara and Glenn H. Sullivan. His research centers on production economics in the NTAE sector, with focus in the floriculture sector. His M.S. degree was completed in Year Eight.

Gustavo Acosta, a native of Mexico with broad experience in Central America, is completing a Master's Degree in Agricultural Economics at Purdue University on a match-funded assistantship under the direction of Drs. Kenneth Foster and Glenn H. Sullivan. His research centers on strategic market development issues for Central America in the NTAE sector. He will complete his degree in Spring 2002.

Networking

Collaborations with APHIS-IS in the development and testing of preinspection programs have helped further expand the IPM CRSP networking activities in Year Eight. This collaboration was strengthened in Year Eight through activities associated with USDA's formal approval of Guatemalan papaya into U.S. markets, and will lead to expanded program development as the Petén Region is targeted for papaya production.

Private sector grower-shippers and shippers of NTAE crops that are participating in the IPM CRSP led initiative became important "technology transfers agents", potentially reaching nearly 13,000 small farm producers, field technicians, and community leaders throughout Guatemala and Central America. This networking activity will continue to be important as the GOG implements regional supply consolidation/preinspection centers, and institutionalizes preinspection protocols and policies.

Networking activities at the district and community levels were expanded in Year Eight. Over 141 households in the Chimaltenango District were surveyed in the Year Eight socioeconomic assessments. Overall the IPM CRSP has networked with over forty communities throughout Guatemala. These collaborations serve as the basis for continuing research and outreach activities. In addition, gender and socioeconomic impact studies were conducted at the community level in Guatemala. This networking activity has greatly enhanced the socioeconomic knowledge base of the IPM CRSP, and is expected to generate important gender, household, and NTAE impact conclusions for publication in Year Eight. Training seminars for NGO's, independent private sector crop management technicians,

and PIPAA personnel focused on the transfer of IPM CRSP pest management strategies and preinspection performance protocols. All training seminars were supplemented with published research materials and user manuals developed by ICTA in collaboration with AGEXPRONT and IPM CRSP researchers.

Institutional networking activities continued in Year Eight as preinspection policies in snow pea were institutionalized for implementation by the GOG. ICTA, MAGA, APHIS, and AGEXPRONT continued to play important collaborative roles in preinspection research, development, and implementation. In addition, PIPAA, a joint MAGA/private sector entity was commissioned by the GOG to handle preinspection program implementation, compliance, and enforcement in Guatemala's NTAE sector. This important networking activity required a substantive commitment from the IPM CRSP in training and knowledge transfers.

The IPM CRSP strengthened networking activities in Honduras in Year Eight, initiating direct communications and site visits with the Minister of Agriculture, the Ministry's Coordinator for Technology Generation, and FHIA. The Minister of Agriculture, Guillermo Alvarado Downing, requested an IPM CRSP developed research proposal to address the issue of plant virus pathogens that cause serious damage to the melon crop in Honduras and agreed to sign an GOH MOU with the IPM CRSP. Melons, particularly cantaloupe during the period January through April, comprise Honduras' most important NTAE crop. However, plant virus diseases currently threaten nearly 11,000 acres of melon for export to the United States valued at over $24 million USD. The IPM CRSP, under the leadership of Drs. Ray Martyn at Purdue University and Maria Mercedes Doyle at Zamorano, responded to Minister Alvarado Downing's request for a research proposal to address these plant disease problems, and a $100,000 USD budget for Year Eight has been given approval.

In Year Eight the IPM CRSP hosted its fourth biannual Central American Regional Seminar for NGO's, technicians, producers, researchers, government officials, and collaborators actively engaged in the NTAE sector. This important networking activity attracted over 210 registered participants from five Central American countries, and served as an important vehicle for reporting IPM CRSP research and transferring IPM / ICM technology throughout the region.

The IPM CRSP continued to strengthen networking activities with the University of Georgia, The National Science and Technology Council in Guatemala, and The National Papaya Growers Association in addressing the ringspot potyvirus in papaya. These networking activities will likely be expanded and strengthened in Year Nine through a stronger collaboration with researchers at the University of Georgia and additional funding.

Research Accomplishments

Institutionalization of the GOG certified preinspection program for trade expansion in the NTAE sector, including performance protocols, supply source tracking, technology transfers, enforcement policies, and grower training, continued to serve as the "cornerstone" of all IPM CRSP related research and training activities in Year Eight. IPM CRSP developed production strategies and performance protocols serve as the foundation upon which all preinspection related GOG programs and policies are established. Collectively, these collaborative research activities have helped reduce grower reliance on chemical pest control methods, improved economic returns to growers, and

enhanced the socioeconomic welfare of NTAE households.

The importance of this research accomplishment centers upon the fact that Guatemala's competitive position in the NTAE sector has suffered since 1995 due to sanitary and phytosanitary violations detected at U.S. ports-of-entry**.** An assessment of U.S. trade data suggests that there is a high correlation between the lack of compliance with the aforementioned non-economic constraints and a decline in Guatemala's competitive position in the U.S. vegetable market. The IPM CRSP is playing a pivotal role in helping reestablish regional competitiveness and trade expansion in the NTAE sector. The overall IPM CRSP objective continues to center on economically sustainable NTAE crop trade expansion in Central America, with less dependency on chemical pest control methods.

In collaboration with APHIS-IS and MAGA, preliminary assessments were conducted by IPM CRSP researchers to evaluate the potential for papaya in the U.S. marketplace. While additional quantification will be necessary, these preliminary assessments found that significant market opportunity does exist, but only for standardized grade at uniform quality on a consistent basis. These findings further concluded that the greatest market opportunity existed for the Hawaiian (solo) type papaya in the Eastern U.S. markets. This preliminary research helped establish the basis for USDA clearance for Guatemalan papaya into the United States, and serves as the basis for serious GOG/APHIS-IS program initiatives for developing papaya production in the Petén Region of Guatemala.

Moreover, the IPM CRSP research collaborations with U. del Valle and the U. of Georgia addressing the papaya ringspot problems in Central America has led to potentially virus free papaya production in 2002. This research has been an important consideration in the GOG/APHIS-IS decision to target the Petén Region, an economically depressed region of Guatemala, for papaya production. Such development compliments the USDA/APHIS/GOG objectives to establish a medfly-free zone between North and South America. Medfly is a potential threat to North American producers, and is now controlled through intensive chemical control methods.

In one of the first studies of its kind, IPM CRSP researchers in collaboration with FAO, INCAP and the GOG are evaluating the health affects of IPM adopter households in the NTAE sector of Guatemala. This research activity builds on prior IPM CRSP research that has helped reduce pesticide applications dramatically, and upon current socioeconomic research that finds NTAE households with better health and education benefits. This study will further quantify the health status of those households which have adopted IPM / ICM technology in NTAE production, and compare the findings with non-adopter households. This progressive IPM CRSP activity serves as a significant baseline study for future research, and potentially significant levels of new funding. Dr. C.R. Edwards, Purdue University, serves as the program leader in this IPM CRSP activity.

As previously stated, Year Eight IPM CRSP research achieved substantive validation of the socioeconomic benefits that accrue from NTAE production and IPM CRSP technology adoption. Findings concluded that adopter households generally witnessed an improved and/or more stable family economic situation, and an improved quality of life, with NTAE production and lower pesticide use. Better health care and education, as well as, higher rates of more stable employment were most

commonly perceived as benefits from NTAE production. Fully 64 percent of all producers surveyed responded that their socioeconomic situation overall was improved from NTAE production.

These "benefits assessments" will be expanded to a larger sample population in Year Nine. However, the benefits to our overall program in Central America are already evident. The GOG has proceeded to move more aggressively on matters that assure long-term institutionalization of IPM / ICM programs in the NTAE sector. The GOG and APHIS-IS have increased efforts to develop NTAE production in the Petén Region, with particular emphasis on papaya production for U.S. markets. And the private sector, under the leadership of ARF/AGEXPRONT, has galvanized efforts to support the institutionalization of preinspection in the NTAE sector of Guatemala, and work to coordinate NTAE trade expansion with GOG policies and initiatives under an "aid through trade" coalition.

The Fourth IPM CRSP Regional Seminar was held in Guatemala City on June 7-8, 2001. Over 210 registered participants from five Central American countries attended. Twenty-eight research presentations were made by IPM CRSP collaborators, including IPM / ICM research findings on snow pea, broccoli, tomato, potato, papaya, melon, alternatives for methyl bromide, and economic/socioeconomic impacts. Clearly, this was the most successful of IPM CRSP seminars and workshops to date, serving as an important medium for technology transfer and future training opportunities (see Addendum).

Substantial research has been conducted in IPM strategies in our target crops of snow pea, broccoli, and tomato with the primary objective to develop science tested IPM programs for improved pest management, reduced pesticide use, more efficiency in pest management and with the final goal of improved markets for NTAE crops. Highlights include:

a) Studies investigating the influence of soil management and threshold based weed management in vegetables. These studies are designed to improve long-term weed management in NTAE crops by integrating cropping practices that reduce weed seed levels in the soil seedbank, and subsequently lower pest pressure.

b) Investigation of the potential for growing organic snow peas for NTAE markets where demand for such produce is increasing. The U.S. market for organic produce reached $7.7 billion in 2000. Primary emphasis in this research is to develop workable production systems by use of non-synthetic chemicals, cropping sequences, trap crops, and biological controls. First year results have been positive and show organic production is possible.

c) Biological control of whitefly in tomato by use of portable sticky traps (torito) as a component of IPM practices for tomato has been positive. The torito technology, which was originally developed for leaf miner adult fly control in snow peas, has been shown to be useful for whitefly control in tomato. Use of the torito in tomato plots every two days reduced whitefly populations and incidence of leaf cell virus, and improved net return compared to intensive chemical insecticide treatments.

d) Research investigating organic materials as substitutes for methyl bromide fumigation in broccoli showed that organic materials coupled with solarization does have some potential for use. Use of wild broccoli species residues, and broccoli residues used with solarization resulted in reduced weed

pressure, improved soil nutrient levels, and improved soil structure. These treatments will be tested further for use especially by small landholder farms where the technique has the greatest potential for adoption. Similar experiments were conducted in tomatoes with use of solarization combined with either chicken manure, tomato stubble, cucumber stubble or as a single treatments compared to intensive chemical use. All treatments showed positive results where biocontrols improved soil fertility. The chicken manure plus solarization treatment resulted in the highest yields.

e) Research was initiated investigating the potential for development of bioclimatic models for control of diamond back moth in broccoli and leaf miner in snow pea. For diamond back moth, research showed population dynamics were correlated with air temperature, humidity, and rainfall. For leaf miners, population dynamics were related to air relative humidity, air temperature, and relative humidity in the leaf canopy. Continuing research in both crops will allow development of models to predict population levels for more precise and effective timing of control techniques and lead to a reduction in pesticide use.

South America Site in Ecuador

Jeff Alwang, Site Chair, Virginia Tech;
Carmen Suárez, Site Coordinator, INIAP;
Victor Barrera, Vice Site Coordinator INIAP

Description of the Collaborative Program

This is the fourth year of activity at the South American site in Ecuador. A total of 12 major activities were conducted during the year. This site operates under a Memorandum of Understanding with INIAP, the research arm of the Ministry of Agriculture in Ecuador. A Site Coordinator and assistant site coordinator manage activities under the CRSP because the crops we work with are primarily located in two locations. Carmen Suárez serves as overall Site Coordinator and focuses on the work in the lower elevations. She is a researcher at the INIAP Tropical Experimental Station at Pichilingue and coordinates plantain and agroforestry activities. Victor Barrera serves as Assistant Site Coordinator and focuses on the higher elevations. He coordinates activities with potato and Andean fruits. Each activity has a leader that is responsible for interactions with their respective coordinators and cooperators.

The work under the CRSP was conducted as a collaborative effort among scientists at INIAP, the International Potato Center (CIP), the Ecuadorian National Potato Program (FORTIPAPA), PROEXANT, the International Food Policy Research Institute (IFPRI), Fundacion Maquipucuna, Eco-Salud, the Soil Management CRSP, the University of Georgia, the Ohio State University, Florida A&M University, and Virginia Tech. The CRSP is developing collaborative ties with the local Universities and we fund student employees and graduate students. Jointly

developed collaborative research plans have allowed us to buy into ongoing research programs and initiate new projects with joint funding.

The Year 8 workplan focused on crops, pests, and constraints identified in the participatory appraisal process. Planning and collaborative research took place through: a) discussions among host country and US/international scientists at planning meetings in Ecuador and Blacksburg, VA, and b) preparation of joint host-country/US/international scientist two-page proposals.

Field research is being conducted in farmers' fields in Chimborazo, Carchi, Tungurahua, El Carmen, Maquipucuna, with INIAP/CIP scientists visiting experiments on a regular basis. Research is also conducted on station, at Sta. Catalina and Pichilingue.

IPM Constraints Addressed

The key constraints addressed in Ecuador in year 8 were the need to identify, and develop IPM solutions to specific pest problems in potato, Andean fruits, and plantain. Additionally, there was demand for information on socioeconomic factors influencing adoption of IPM and mechanisms for diffusion of IPM technologies in potato. Specific major pests being addressed in the IPM program are Late Blight (*Phytophthora infestans*), Andean Weevil (*Premnotrypes vorax*), and Central American Tuber Moth (*Tecia solanivora*) in potato; Babaco and Narajilla Vascular Wilt (caused by *Fusarium oxysporum*) and other pathogens in Andean fruits; and Black Sigatoka (caused by *Micosphaerela fijensis*), the bacteria *Erwina* sp., and several insect pests in plantain. The work in Maquipucuna focused on identifying and evaluating IPM solutions to pest problems in a mixed coffee and plantain system.

The site is thus addressing some of the known production constraints of some key horticultural staples in the area. *Phytophthora infestans* is a worldwide limiting factor in potato production. Andean fruits are a source of healthful food for the entire nation, and have potential for export. However, mites, nematodes, fruit and stem borers, and especially diseases such as *Fusarium* vascular wilt have made it difficult to produce these fruits economically. Vascular wilt in naranjilla has caused the collapse of the native variety in many places in Ecuador. Plantain is a staple food for people living in the littoral (lowland Tropics). In fact, plantain is a substitute for potatoes at the lower elevations.

The plantain research is especially important, as there has been very little study worldwide of IPM practices for plantain. It was originally assumed that many banana practices could be directly transferred to plantain. However, our research is showing that not to be the case. One objective of the research in the plantain pest-survey is the identification and quantification of nematodes associated with this crop. This is the first such investigation of its kind of which we are aware.

Selected Research Accomplishments

This year, the Ecuadorian site has had several significant accomplishments:

The primary soilborne pathogens affecting potato in Southern Ecuador have been identified.

A promising entomopathogenic means of controlling Andean Weevil in potato has been identified.

Alternative means of controlling Andean Weevil in potato through more limited use of

Triflumuron have been identified and tested. This field-based study builds upon research findings from previous years.

Several potato cultivars have been identified that are acceptable to consumers, and have strong (horizontal) resistance to late blight. A survey of the incidence and importance of the major potato diseases has also been conducted.

Grafting techniques for Babaco have been tested. Babaco rootstocks that are resistant to *F. oxysporum* appear to have promise for control of the disease. These rootstocks have been identified and tested.

Techniques for mass breeding of acari have been established for biological control of fruit mites on Babaco.

The etiology, plant resistance and seed-borne transmission of Naranjilla Vascular Wilt have been established. Control measures are now being identified; the most appropriate control method appears to be plant resistance to *F. oxysporum*.

Field-level control of *B. castanesu* in blackberry has been established. Mass-production techniques for entomopathogens have also been identified.

Experiments began to identify pests and means of their control in a plantain/coffee agroforestry system near Maquipucuna. The study is providing information on appropriate IPM strategy for main crops in a very fragile area.

Problems in plantains, and strategies for their control, have been shown, contrary to prior expectations, to be different from those of bananas.

A strategy for control of Black Sigatoka in plantain has been identified. Fungicide application, together with other management practices, needs further investigation.

More information is needed before recommendations can be made for the control of Black Weevil (*Cosmopolites sordidus*) in plantain. However, the medium and container for distribution of the entomopathogenic fungi *Beauveria bassania* has been prepared for field testing. This biological control has promise in the control of the weevil.

Methods for trapping Black Weevil in plantain have been evaluated. Certain trapping systems have been identified as most promising and more work needs to be done to establish viability of the overall system.

Procedures for nematode sampling and counting have been established together with a protocol for future identification of nematodes in plantain.

Seven farmer field schools have been established in the principal potato-growing regions: 5 in Carchi and 2 in Bolivar. IPM techniques are being disseminated by the 136 field school participants. Several workshops have been conducted and the methodology is being extended to other potato-growing areas of Ecuador.

Information on IPM knowledge and practices in Carchi has been produced. A sample survey of 60 households has been analyzed. The survey contains information on agricultural practices, household demographics, and pest management practices. These data are being merged with data on illness and more detailed information on the impacts of pesticide use on household members.

Impacts of changes in pest management technologies in potato have been measured. It is estimated that in the Central Region of Ecuador, the net present value of IPM control of the Andean Weevil is $US 357,000. Ecuadorean technicians have been trained in impact evaluation.

Mutuality of Benefits of the Research

The results of the plantain research will have benefits in Ecuador and to the region. The U.S. and Europe are becoming major importers of plantain and as production increases relative prices will encourage and expand global acceptance.

Potato research to find clones which are long-term resistant to late blight and that are highly acceptable to consumers will benefit Ecuador, the region and the world. This is a top priority for North America as well as in South America.

The work on Andean Fruit is pioneering IPM methods for pest control on these important crops. Naranjilla, Babaco and Blackberry all have export potential, but exportability is being limited by diseases. Information from project will help avoid the introduction of pathogens into other areas of naranjilla production in Ecuador and other areas of Central and South America.

The socioeconomic studies will provide information related to pest management and its impacts on household economic and health well being. This information will be of use in evaluating the feasibility and impacts of IPM throughout the Andean region.

Institution Building

Collaborative research and financial support have directly benefited institutions in Ecuador.

Several Ecuadorian undergraduate and graduate students are being funded through activities of the CRSP for their Independent Study theses and their MS theses from Ecuadorian Universities. This system is helping the CRSP and the Universities to conduct research and to train individuals in applied agricultural research.

Mr. I. Carrasco received his degree from the Technical University of Bolivar and received training in the identification and mass production of *B. Castaneus*.

Ms. B. Yangari wrote a thesis at Catholic University based on her research on naranjilla vascular wilt.

Mr. D. Quishpe finished his thesis work conducting an IPM impact assessment.

Mr. P. Landuazui attended a biostatistics and IPM course at the Escuela Superior Politecnica del Ejercito. Mr. M. Freire received training on IPM while working on the IPM-CRSP.Mr. P. Gallegos of INIAP/Santa Catalina spent 2 months at Ohio State University to carry out IPM-related training and practical work. Ms. M. Arias, an entomologist from INIAP's Boliche Station received practical training in the identification of acari species. Several university and INIAP researchers were involved in the naranjilla vascular wilt study, including Ms. V. Galarza from Central University and Mr. J Fiallos from the Palora Experiment Station. Numerous investigator interchanges occurred in the conduct of the socioeconomic studies. Twenty technicians from INIAP. CIP, Central University, IASA and the Polytechnic School of Chimborazo were trained in the use and management of instruments for systems analysis. Ms. M. Crizon received training in participatory gender analysis, and technicians

from UVTT-Carchi interacted with professionals in institution-building exercises.

Mr. J. Suquillo of INIAP participated in a course related to farmer field schools in El Salvador during 2001. Mr. L. Escudero, J. Suquillo and F. Chulde facilitated training of trainers course on IPM held in Carchi between March and August 2001. These three then traveled to Bolivar to share experiences with field workers there.

Ms. S. Garces began graduate studies in entomology at the Ohio State University in November, 2001.

Networking

The IPM CRSP is part of several projects managed by the National Potato Program of INIAP. Work on potatoes is coordinated through the INIAP-PNRT Annual Plan and interacts directly with CIP, the Soil's CRSP, Eco-soil, and Fortipapa.

The fruit work is being coordinated through INIAP's department of fruit culture. Other professionals from universities and in research organizations who are working on fruits regularly interact with CRSP researchers. Ongoing research on fruit is being conducted in conjunction with work on INIAP experiment stations.

Studies of biological control were conducted in collaboration with the Catholic University of Ecuador and the Investigation Support Office from France. The collaborating institutions shared information, Baculovirus strains, and fieldwork.

Plantain activities have been coordinated with INIBAP (the international banana research center). The plantain work has also involved local agricultural high schools and universities. Plantain work includes interactions with IGN (the military geographic institute), CLIRSEN (the Ecuadorian remote sensing institute), the Ecuadorian foundation for ecological studies, and others.

Activities in Maquipucuna are being conducted jointly with the University of Georgia, Fundacion Maquipucuna, and the "Choco-Andino Corridor" project, a large multi-institutional integrated project. Workshops have been held in the Biology Department of the National Polytechnic School.

On May 23, 2001; INIAP, CIP, SM-CRSP, IPM-CRSP and Eco-health project offered a workshop on the "Impacts of the use of pesticides in Carchi" at the Quito Hotel in Quito, with participation of 80 people. A compendium of presentations is expected to be published in the next few months. On August 3, 2001, INIAP, CIP, SM-CRSP, and IPM-CRSP offered a workshop about the "Use and management of the Tradeoffs model as an instrument for political decision taking", at Santa Catalina – INIAP, with the participation of 12 technicians from INIAP and CIP. The impact assessment was conducted jointly with IFPRI and in collaboration with the Soils CRSP and CIP.

María Crizón and José Romo are participating in the Course of Training of Trainers on the integrated management of the crop and in the methods of the Field Schools, implemented by IPM-CRSP and FAO in the province of Carchi. IPM-CRSP personnel participated in the health week about the use and adequate management of pesticides inside the house, in San Francisco de la Libertad in Carchi.

ASIA REGION

South Asia Site in Bangladesh

George Norton, Site Chair, Virginia Tech; Rezaul Karim, Site Coordinator, Horticultural Research Center, BARI

Description of the Collaborative Program

IPM activities in the Bangladesh site were concentrated in three program areas during year 8, which was year 3 for Bangladesh. The first of these areas was crop monitoring, the second was multidisciplinary pest management experiments, and the third was socioeconomic analyses. The work was conducted as a collaborative effort among scientists at the Bangladesh Agricultural Research Institute (BARI), the Bangladesh Rice Research Institute (BRRI), the Asian Vegetable Research and Development Center (AVRDC), the International Rice Research Institute (IRRI), the University of the Philippines-Los Banos, Penn State University, Purdue University, and Virginia Tech. Rezaul Karim served as Site Coordinator and George Norton served as Site Chair.

The Years 8 work plan focused on crops, pests, and constraints identified in the participatory appraisal process and in the previous year's crop-pest monitoring. Pest management experiments and socioeconomic analyses were refined using knowledge gained in the first two years. Planning and collaborative research took place through: a) discussions among host country and US/international scientists at planning meetings in Bangladesh and b) preparation of joint host-country/US international scientist two-page proposals. Planning for Year 9 also involved discussion of the plans jointly with scientists working in the Philippine site during the planning workshop at Virginia Tech in May 2001.

Field research is conducted in farmers' fields in Kashimpur, with BARI/BRRI scientists visiting experiments on a regular basis. Some research is also conducted on station, especially varietal screening for insect, disease, and nematode resistance in eggplant and tomato. Training takes place primarily at U.S. universities UPLB and AVRDC. CARE-Bangladesh has participated in the planning but not the research, but is now expressing interest in increased involvement in disseminating results.

Pest management research encompassed three thrusts. The first thrust was a continuation of crop monitoring for the third and final year. The second thrust included various manipulations of the host plant to provide disease and insect resistance (varietal screening, rootstock grafting, hybrid production). The third thrust involved investigations of the effectiveness of various IPM tactics against key pests in various vegetable crops (soft pesticide timing, nylon net barriers, virus infection timing, fruit fly bait trapping, soil amendments against soil-borne disease and biological control).

Socioeconomic studies included a continuation of the analysis of vegetable market prices on IPM adoption, patterns of pesticide expenditures on vegetable farms, impact assessment, and the role of farm women in IPM decision making.

IPM Constraints Addressed

The key constraints addressed in Bangladesh in year 8 were the need for IPM solutions to specific pest problems in vegetables and the need for information on socioeconomic factors influencing adoption of IPM. Specific major pests being addressed in the IPM program included fruit and shoot borer (*Leucinodes orbinalis*) and bacterial wilt

(*Pseudomones solanacearum*) and other pathogens in eggplant, various weeds in cabbage and eggplant, aphids and diamond back moth in cabbage, and soil borne pathogens such as root knot nematodes (*Meloidogyne* sp) and *Fusarium* in gourds.

Selected Examples of Research Progress and Results

Detailed descriptions of research progress and results are provided in the individual institution activity reports. The following is a bring summary of research progress and results:

Monitoring of crop pests and their natural enemies in rice and especially in vegetables (eggplant, tomato, cabbage, Okra, Gourds, and yard-long beans) identified the most serious insects, diseases, and weeds in the Gazipur district. Shoot and fruit borer in eggplant and fruit borer in lady's finger were abundant. Diamond-back moth was common in cabbage. Fruit fly infestation was high in tisssel gourd, sweet gourd, cucumber, bottle gourd and bitter gourd. Aphids were highly abundant in country bean and tomato. Among the diseases, eggplant was highly susceptible to bacterial wilt and phomosis blight, and mosaic virus in cucurbit vegetables. Yellow mosaic virus infection was very high in okra. Farmers used insecticides and fungicides frequently at high doses. Weeds were also a serious problem of vegetables. The predominant weed species were *Cyperus rotundus*, *Lindernia anagallis*, *Digitaria sanguinalis* and *Commelina diffusa*. Farmers controlled the weeds by intensive hand weeding at fortnightly interval, which were very costly and laborious. A suitable schedule of weeding is needed to reduce the weeding cost.

Evaluation of the selected eggplant and tomato varieties produced very promising results this year. Against bacterial wilt disease, ten eggplant varieties showed resistant reactions; five of them were also resistant last year. None of the tomato entries, however, was resistant to BW. All of the ten selected eggplant varieties exhibited resistance to RKN which include two cultivated varieties. Among the test tomato varieties, 9 were moderately resistant to RKN; two of them also produced the same reaction last year. Among the 31 tomato varieties tested against YLCV disease, 9 were selected as resistant and 13 as moderately resistant; 8 of these selected ones are improved BARI varieties recommended for on-farm use. Five eggplant varieties were selected from the field trials having high resistance to FSB, 3 as resistant and 10 as moderately resistant. From the same trial, one resistant and 12 moderately resistant eggplant varieties were selected against jassids. Several of the eggplant varieties have multiple resistance to different pests.

Grafting of cultivated eggplants or tomatoes was highly compatible; grafting success was more than 91% for eggplants and 98% for tomatoes. None of the eggplant or tomato grafts were affected by BW disease. Under field conditions, eggplant grafts produced 40-63% and tomato grafts 7-14% more yields than the non-grafted plants.

The genetic variability and nature of combining ability as well as heterotic performance for eight characters were estimated in 21 hybrids of eggplant (*Solanum melongena* L.) involving seven parents. The general and specific combining ability (gca and sca) variance and effects for all the characters showed the predominance of additive gene action. The parents BL081, BLS_2 and BL034 appeared to be the best combiners for yield/plant, and the parents BL034, Mixture and Uttara were the best combiners for fruits/plant. The parent

Islampuri was the best combiner for fruit diameter and individual fruit weight. The hybrids BL083 × BL081, Uttara × BLS_2, Islampuri × BL034, BL081 × BLS_2 and Islampuri × BL081 showed significant positive sca effects for fruits/plant. The best crosses with the highest estimates of sca effects for fruit yield/plant were Uttara × BLS_2, BL083 × BL081, BL081 × BLS_2 and Islampuri × BL034. An additional 78 hybrids have been developed in 2000-2001through half-diallel crosses involving 13 selected parents. Selection of high yielding, pest-resistant hybrids from these materials will lead to the development improved eggplant varieties.

The infestation rate of the leaf-eating lepidopteran pests was moderate, the lowest being 4.9% in plots receiving IPM treatments, followed by treatments of farmer practice (10.2%) and untreated control (14.1%). In spite of moderate infestation levels, plots receiving IPM treatments had 65% lower infestation and 18.5% higher yield than that of the untreated control, as compared to 28% lower infestation and only 8.6% better yields in plots managed by the farmers. The results demonstrated that healthy, pesticide-free cabbage crops can be produced by undertaking IPM practices.

Cabbage heads in plots having net barrier on the sides and the top, or only around the sides with an open top had, respectively, about 91% and 86% less infestation of cabbage leaf-eating pests and produced 16% and 12% more yields than those having no net barriers. Although the net barrier method produced pesticide-free, healthy cabbage crop, the returns from the additional cabbage production could not, however, justify the cost of net barriers.

Exclusion of the vectors (jassids and white fly) of okra yellow mosaic virus by the use of 2m high net barrier around the okra plots, until the plants were one month old or more, decreased the populations of jassids and virus infected plants of both the resistant and susceptible okra varieties. Low virus infection in plots netted for 4-weeks or more resulted in 3 to 3.5 times higher yield in the resistant variety and 2 to 2.25 times higher yield in the susceptible variety than that of the untreated control (non-netted). Netting, however, did not show any effect on white fly population in the plots, indicating that the flight height of the white flies was probably more than 2m. The results suggest that virus infection in okra plants occurs at growth stages earlier than four weeks.

Bait traps of Cuelure pheromone and mashed sweet gourd (MSG) in cucumber and sweet gourd crops attracted large numbers of fruit flies resulting in more than a 50% reduction in fruit fly infestation and damage to the fruits, and producing more than a two-fold increase in yield of the crops compared to the non-baited fields. The technique was highly effective for the control of fruit fly and production of cucurbit crops free of pesticides. Continuous mass-trapping tended to diminish fruit fly population in the area.

Soil amendment treatments, such incorporation of poultry refuse, mustard-oil cake, neem-oil cake and burning of sawdust were highly effective in controlling soil-borne pathogens in vegetable seedbeds and fields. These practices reduced the disease-induced plant mortalities, enhanced plant growth and yields, and brought higher economic returns to the farmers. Among the treatments, the use of poultry refuse and mustard –oil cake showed the best results. Laboratory tests showed that poultry refuse and mustard-oil cake contain components that inhibit fungal growth and cause high mortalities to RKN larvae.

The life span of FSB larval parasite, *T. flavoorbitalis*, is about 16 days. The adults survive for five days. The parasite can be reared in the laboratory on FSB larvae and is capable of parasitizing FSB larvae under greenhouse conditions.

Weekly monitoring of the prices of 45 kinds of vegetables at farm gate, wholesale and retail markets in the districts of Gazipur, Dhaka, Comilla and Jessore during 2000-2001 showed that the prices fluctuated greatly depending upon their availability. Seasonality of vegetable cultivation was the major factor for availability; a few vegetables are grown all year and some in particular seasons. Many of the vegetables suffered blemish from the attack of insects and diseases; farmers and the traders incurred 12-24% loss in marketing such vegetables. The farmers and the traders recognized that effective pest control measures in vegetable cultivation could bring them more profit from vegetable farming and its business.

Patterns of pesticide expenditure on rice and vegetable farms were studied in Bangladesh. Data came from a 1998/99 survey of 400 farm households. We focused on understanding the factors that help explain observed variation in patterns of pesticide expenditure. Three regression equations were estimated. Controlling for farmer characteristics, the results revealed positive and significant correlation between pesticide expenditures per hectare and farm size, non-agricultural income, and degree of vegetable commercialization. Access to credit was found to have no explanatory power in the regressions. Farmers' estimates of pest infestation and damage were only weakly correlated with pesticide expenditures.

A study of the role of women in pest management decision making documented several patterns. Contrary to previous opinion, women's farm work was not confined to post-harvest activities, but included pre-harvest responsibilities also. As part of these responsibilities women played an important role in pest management decisions for the vegetable crops. One disappointing finding was that as women's vegetable pest management responsibility grew they were turning to single tactic, chemically-oriented approaches, anathema to an IPM approach. Future vegetable IPM extension programs should be gender sensitive, use a 'farm family' approach in building extension audiences and provide specific vegetable IPM training for women.

Mutuality of Benefits of the Research

The pest problems assessed in these studies are widespread throughout Asia and also occur in other parts of the world. IPM approaches to manage these problems have broad applicability, especially in Asia. The consumption of vegetables is growing in Bangladesh and the region. The primary feedback in terms of benefits to the United States will be through (a) the effects of economic growth in the region on trade and demand for U.S. products in international markets and (b) improved relations with a major country in a politically sensitive area of the world.

Institution Building

Equipment, vehicles, and other support

Funds were provided for vehicle repair and rental to facilitate transport to and from research sites. Computers, copier, supplies, etc were provided.

Research training

One Bangladeshi student, C. Mahmoud, completed his Ph.D. dissertation at Purdue

University (agricultural economics) assessing the economic aspects of the IPM program. One student at Penn State completed his dissertation research in sociology with a focus on the role of women in IPM adoption in Bangladesh. One U.S. student, Thomas Debass completed his MS thesis and degree in agricultural economics at Virginia Tech. One Bangladeshi student, Nazrul Islam began is MS training in weed science at UPLB in the Philippines. One Bangladeshi student, F. Zaman, began his master's degree program at Penn State in Entomology. One Bangladeshi student, Ms. Nahar, began extensive training at Ohio State in support of her Ph. D. degree at the Bangladesh Agricultural Technology University. One scientist, A. Karim, traveled to UPLB for a study leave on weed management.

Scientist travel

E. Rajotte, G. Luther, G. Norton, S. Miller, L. Black, G. Shively, and A. Baltazar traveled to Bangladesh in January to review research results and help plan additional research. Shively visited also collaborated with host country scientists on marketing issues as they affect IPM (his graduate student, C. Mahmoud, also went). S.K. DeDatta traveled to Bangladesh in December 2000 to review research progress. R. Karim traveled to the United States and Virginia Tech to participate in the IPM CRSP annual workshop and planning meeting and to discuss administrative issues.

Human resource development

A human resource development plan for the next three years was revised that includes both short-term and degree training.

Networking Activities

Networking is accomplished through institutional collaboration among BARI, BRRI, UPLB, the Institute of Post Graduate Studies in Bangladesh (IPSA), CARE-Bangladesh, and IRRI-Bangladesh. Both IRRI and AVRDC play key role in networking with other countries in the region. Scientists involved in the project work throughout the region and can spread research results through visits to other countries and participation in workshops, meetings, and other networking activities. U.S. universities also help with networking in the region. Some of the scientists on the project also work with the Philippines site, including the weed scientist from UPLB working in the Bangladesh site. The site coordinator has networked with many other host country and foreign-supported projects in the country, both hosting them at the IPM CRSP site, and attending meetings in which multiple organizations are represented.

Research Accomplishments

Research progress and key results for the past year are summarized above. Among those listed, the success with the eggplant and tomato grafting program against bacterial wilt is particularly significant, as were the results of the soil amendment experiments to reduce soil-borne diseases in vegetables, and the use of bait traps to reduce fruit fly problems in gourds. In addition, during the past year, the results of IPM CRSP Research was highlighted in a day-long meeting/ field day in January that was attended by 200 people, including farmers, including key government officials such as the Minister of Agriculture, a member of parliament, other local politicians, BARI scientists and administrators, and representatives from CARE, USAID, and other agencies. The Minister gave a speech in support of the IPM program, which was televised.

Southeast Asia Site in the Philippines

Sally Miller, Site Chair, Ohio State University;
Aurora M. Baltazar, Site Coordinator, PhilRice

Program Description

IPM activities in the Philippines site were concentrated in four program areas during Year 8: multi-disciplinary on-farm pest management experiments, multi-disciplinary laboratory, greenhouse and micro-plot experiments, socioeconomic analysis and training, and IPM technology transfer and feedback

The work was done as a collaborative effort among scientists at the Philippine Rice Research Institute (PhilRice), the University of the Philippines-Los Baños, the International Rice Research Institute (IRRI), the Asian Vegetable Research and Development Center (AVRDC), Ohio State University, Penn State University and Virginia Tech.

The Philippines site IPM CRSP was successful in Year 7 in obtaining approval for P.L. 480 funds. The 5-year, $ U.S.1.3 million grant entitled "Enhancing the Implementation of IPM to Improve Farmer Competitiveness, Minimize Environmental Risks and Insure Food Security and Safety", was scheduled to begin in January 2001. However, due to fiscal problems in the Philippines government, the allocation of funds has been delayed until January, 2002. The total funding level may also be decreased, in which case the following original objectives will be modified accordingly: 1) Explore and implement IPM technologies and generate new technologies for high-value vegetable crops for reduced pesticide misuse, increased farm product marketability, and farm profitability; 2) Develop transgenic crops for improved vegetable production; 3) Assess economic aspects of improved IPM technologies in rice-vegetable production among small farm units; and 4) Develop training materials and implement season-long vegetable collaborative IPM programs. The principle focus of the P.L. 480 project, which will be seamlessly incorporated into the current IPM CRSP program, is on vegetable IPM in rice-vegetable systems.

The Year 8 workplan was focused on crops, pests and constraints identified in the participatory appraisal process, a structured baseline survey and crop monitoring in years two through four. Planning and collaborative research efforts for the year took place through: discussions among U.S., Philippine and other cooperating scientists at planning meetings in the Philippines, joint host-country/U.S. scientist two-page proposals, a workshop among cooperating scientists to integrate the two page proposals into the overall plan and budget, and revisions to the plan followed by review by the scientists, ME and USAID.

Field research is conducted in six villages in San Jose, Nueva Ecija, in Bongabon, Nueva Ecija, and at the PhilRice experimental farm, also in Nueva Ecija. The host country site coordinator oversees the field research activities. U.S., UPLB, VISCA, IRRI and AVRDC scientists visit the sites periodically to address specific projects. Laboratory and field research is also conducted at AVRDC in Taiwan, and training activities take place at Virginia Tech, Ohio State, Penn State, UPLB and AVRDC.

IPM Constraints Studied

Key constraints to IPM in the Philippines that were addresses during Year 8 were:

- absence of economical IPM solutions for specific pest problems,
- lack of basic understanding of the biology of specific pests,
- lack of knowledge of sources of germplasm for resistance to insects, pathogens and nematodes, and
- absence of knowledge about policies, sociocultural beliefs and perceptions, regulations and other factors influencing pest management practices.

Specific major pests being addressed in the IPM program are the root knot nematode (*Meloidogyne graminicola*), bulb rot (*Fusarium* spp.), pink root (*Phoma terrestris*), anthracnose (*Colletotrichum* sp.), cutworms and armyworm (*Spodoptera* spp.) and various weeds, particularly *Cyperus rotundus*, in onions. In eggplant, fruit and shoot borers (*Leucinodes orbinalis*), leafhoppers (*Amrasca biguttula*) and bacterial wilt (*Ralstonia solanacearum*) were studied. Research on pathogens causing anthracnose (*Colletotrichum* spp.) and bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria*) of pepper were added beginning in Year 7.

Selected Accomplishments

Descriptions of research progress and results are provided in the individual institution/activity reports. The following are examples of progress and key results obtained in the Philippines site.

Postplant application of herbicides using a shielded sprayer or a paintbrush or rollerbrush followed by one handweeding controlled weeds and increased yields over those of plants treated with preplant application of herbicide or those of untreated plants.

A multi-season study on the effects of a net barrier on exclusion of the eggplant fruit and shoot borer, done in conjunction with similar experiments at the IPM CRSP Bangladesh site and other southeast Asian areas, was completed in Year 8. The use of the net barrier, combined with weekly removal of damaged fruits and shoots, reduced *L. orbonalis* infestation (percent damaged fruit) better than the net barrier alone. Both had less damaged fruit than the control.

The onion leaf miner *Liriomyza trifolii* is a relatively recent problem in Luzon but has caused great concern among growers because its damage to onion leaves is highly visible. Consequently, farmers began to apply insecticides intensively in attempts to reduce the level of infestation. Studies conducted in Bongabon, Nueva Ecija demonstrated that commonly used insecticides did not control the leaf miner but reduced beneficial predators and parasites. In addition, the use of insecticides did not increase onion yield. Therefore, preliminary results indicate that insecticide application may be unnecessary.

Nuclear Polyhedrosis Virus (NPV-CRSP) wettable powder (WP) formulation exhibited high potential as an alternative pest management strategy against *Spodoptera litura* compared to the farmer's practice of applying chemical insecticides. The number of larvae and leaf damage obtained from the field plots treated with NPV-CRSP were not significantly different from the plots treated with chemical insecticide.

Bacterial wilt is a devastating disease of eggplant in tropical and subtropical regions throughout the world. Most commercial varieties are moderately or highly susceptible to bacterial wilt. In a project that parallels work being done in the Bangladesh site, we determined that grafting susceptible commercial eggplant varieties onto either of the two bacterial wilt-resistant rootstocks tested reduced disease incidence and increased yield compared to the varieties

grown without grafting. Several varieties, plant introductions or breeding lines were moderately or highly resistant to bacterial wilt, but reactions were inconsistent between the two test locations.

Application of insecticides against the eggplant fruit and shoot borer can reach more than 60 per growing season, often without adequate control. Resistance to this pest and to leafhoppers is a highly desirable component of an IPM program. During Year 8 eggplant varieties, accessions and breeding lines were identified with resistance to one or both of these pests. Accession A-300 was selected and used as a parent for 19 crosses with desirable eggplant lines.

Vesicular arbuscular mycorrhizal (VAM) fungi enhanced the growth and yield of onion when applied at seeding, even in the presence of nematodes in the soil. In nematode-free soil, a mixture of VAM fungi increased the bulb weight and diameter of Yellow Granex by 54% and 24%, respectively, and that of Red Creole by 23% and 13%. In the presence of *M. graminicola*, bulb weight of Yellow Granex onion increased by 262% and bulb diameter by 96.4%. *Bacillus* sp. strains APP 48, LEP 118, and PG 14 reduced the penetration of *M. graminicola* in onion roots.

Anthracnose of onion, caused by *Colletotrichum gloeosporioides*, has emerged during the past two years as a major production constraint. Information on relative resistance of commercial onion cultivars is lacking. In replicated field trials carried out in Year 8, differences were observed among varieties in resistance to this pathogen. Tanduyong, Robins 7, Robins 77 and Condor were rated resistant or highly resistant. In a separate trial, Tanduyong was one on the cultivars most susceptible to pink root (*Phoma terrestris*), while Condor, Robins and Niagara were the most resistant.

Fourteen onion cultivars were evaluated for resistance to pink root in a naturally infested field in Bongabon, Nueva Ecija from January to April 2001. Out of the fourteen onion cultivars tested, Niagara, Condor and, Robins (Yellow) had the lowest incidence of pink root while Rushmore and Shallot (Tanduyong) had the highest incidence. Higher yield was observed in onions grown in plots burned with rice hulls as compared to unburned plots.

Colletotrichum gloeosporioides and *C. capsici* were isolated from infected pepper leaves and fruits collected from Ilocos Norte and Benguet Provinces. *Xanthomonas campestri* pv. *vesicatoria* was also isolated from all leaf samples. Anthracnose was reduced by application of mancozeb and azoxystrobin.

The amount of insecticide applied against the onion cutworm, *Spodoptera litura* in onion was substantially reduced when insecticide spray was properly timed using sex pheromone baited traps. A single application at the proper time gave the same yield as weekly sprays.

It is a normal practice for farmers in Nueva Ecija to spray insecticides several times in the seedbed and immediately after transplanting to control defoliating insects. However, onion was found to compensate for early season damage caused by defoliators. This information may lead to a significant reduction in insecticide use.

The bacterial antagonist *Bacillus* sp. LEP 118 showed potential to control bulb rot and other soil-borne pathogens onion and can be more effective if applied as soil drenched suspensions or protective coatings to the root surface.

Economic impact analysis showed at the farm level that different alternatives proposed to manage weeds in onion were favorable in terms of increasing profit due to higher yields and lower cost of the alternative strategies. A bigger share went to consumers as a result of lower price due to research-induced shift in the supply curve. These results have major implications in terms of the savings from capital investment as well as net profits. The adoption of these alternatives will reduce the pesticide loading of the environment because these are non- or low-herbicide using technologies.

The possible social impacts of advocating weed management strategies, specifically, rice hull burning (RHB) and stale seedbed technique (SST) in Barangay Palestina, San Jose City, Nueva Ecija and Barangay Kaingin, Bongabon, Nueva Ecija, were assessed using Krawetz SIA Model. RHB offers many advantages, however, further studies should be conducted to determine its effect on health and environment. Rice hull supply and road accessibility are additional factors to consider for its adaptation. SST was determined to be a socially acceptable practice.

In a season-long farm level integration study, herbicide and insecticide application and handweeding were reduced by 25 to 50% with the integration of alternative IPM strategies, without reducing yields and income of farmers. The alternative IPM strategies reduced costs by 7%, yields increased by up to 15% in two sites and net income increased by as much as 15 to 23% in Palestina, San Jose and Bongabon. No yield increase was obtained in Sto. Tomas, San Jose but income increased by 15% due to the reduction in costs in insecticide application.

Mutuality of Benefits of the Research

Most of the pest problems addressed in the Philippines site activities are widespread throughout Asia and also occur in other parts of the world. Strategies developed to manage these pests economically and sustainably can thus be applied to other countries. IPM methods developed for managing pests of onion and eggplant are particular examples. We are currently cooperating with IPM CRSP Bangladesh and AVRDC through the GDZ-funded Periurban Project in development of eggplant grafting technologies to manage bacterial wilt disease. Economic and social impact analyses have shown that strategies such as the use of stale seedbed technology are socially acceptable and economically beneficial to farmers in Central Luzon. These strategies are likely to benefit farmers in other Asian countries as well in the near term, and have the potential to be adopted in other regions.

Institution Building

Funds were provided for long-term rental of a vehicle for travel to and from research sites. U.S. scientists also provided research supplies during visits to the Philippines site. Research articles were sent from U.S. cooperators, and bibliographies were prepared at Penn State and provided to IPM CRSP scientists. Approximately 50% of the total Philippines site budget was allocated to PhilRice and cooperating institutions in the Philippines. Technology transfer activities of PhilRice, previously devoted exclusively to rice production, continued to expand significantly in Year 8 to include vegetable IPM. The addition of P.L. 480 funds will secure the inclusion and expansion of vegetable IPM research in the programs of PhilRice and related institutions.

Human Resource Development

Several students are currently being supported by the project in graduate programs in a collaborating host country university (UPLB) or U.S. institutions. Edwin Martin is pursuing an M.S. degree in weed science at UPLB, and completed training at Virginia Tech under Dr. L. Kok. Jean Recta is pursuing a Ph.D. in statistics, and Irene Tanzo is pursuing a Ph.D. degree in rural sociology at Penn State. Cesar Mamaril earned an M.S. degree in agricultural economics at Virginia Tech. Evelyn Gergon earned a Ph.D. degree in plant pathology/nematology at UPLB in Year 8. Salve Santiago completed a short-term training on eggplant grafting at the IPM CRSP Bangladesh site in October, 2000.

Networking Activities

Networking is accomplished through institutional collaboration between PhilRice, UPLB, VISCA and other agricultural colleges in the Philippines. PhilRice is part of the Department of Agriculture (DA) and its national IPM program coordinates with IPM CRSP. Regional networking was also accomplished by attendance and presentation of papers by IPM CRSP scientists at regional meetings in Asia. Participation during Year 8 includes:

- A.M. Baltazar and M.C. Casimero attended and presented papers at the 18th APWSS conference held in Beijing, China on May 28-June 2, 2001.

- M.C. Casimero and J. M. Ramos attended and presented papers at the Pest Management Council of the Philippines conference in Pili, Camarines Sur on May 2-5, 2001.

- M.C. Casimero attended and presented papers at the Asian Agriculture Congress in Manila, Philippines on April 24-27, 2001.

- G. Arida and R. Alberto served as resource speakers for 28 Muslim extension workers in the "Specialized Training Course on Rice and Rice-Based Crops Production for Muslim Trainers and Extension Workers". IPM for tomato and eggplant, 01 March 2001, PhilRice, Muñoz, Nueva Ecija.

- Results of the preliminary onion leaf miner study were presented by D. Arida and discussed with farmer members of the onion growers' cooperative NOGROCOMA, and agricultural technicians in Bongabon, Nueva Ecija during a meeting held on 20 July 2001.

- N. Opina was a resource speaker in a training on rice-eggplant/okra cropping patterns in Brgy Lipay, Villasis, Pangasinan, September 5, 2001.

- E. Gergon participated in a training workshop on mycorrrhizae sponsored by the Mycological Society of the Philippines in the Plant Pathology Department, UPLB, College, Laguna**,** March 17-19, 2001.

Technology Transfer

Technology transfer activities were extensive during Year 8. These activities were carried out in cooperation with the Training Division of PhilRice, in both organization of meetings and preparation of training materials for season-long training programs for Provincial and Municipal Agricultural Officers, representatives from Local Government Units and farmer leaders. IPM CRSP scientists were active participants in these training programs; titles of specific presentations are

included in project reports. Specific programs and materials include:

- Rice-based upland crops training for Mindanao agricultural officers and extension workers, January, 2001.
- Quarterly meetings with NOGROCOMA farmers.
- Village-level integration studies with a rice-based program, headed by M. Casimero.
- One vegetable IPM training manual and 20 leaflets and fact sheets

Publications

Selected publications representing the contributions of the IPM CRSP Philippines site to reviewed journals and other venues follow:

Caasi-Lit, M.T., V. P. Gapud, B. A. Santiago, C. V. Pile, G. E. Balagot, N. S. Talekar and E. Rajotte. " Resistance Screening of Farmers' and Commercial varieties of eggplant against the leafhopper, *Amrasca biguttula* (Ishida). Poster paper presented during the 23rd Annual Scientific of the National Academy of Science and Technology. Manila Hotel 5-6 July 2000.

Casimero, M.C., A.M. Baltazar, J.S. Manuel, S.R. Obien, and S.K. De Datta. 2001. Population dynamics and growth of weeds in rice-onion systems in response to chemical and cultural control methods. Proceedings of the 18th Asian-Pacific Weed Science Society conference. Beijing, China. May 28-June 2, 2001. Pp 48-56.

Baltazar, A.M., E.C. Martin, A.M. Mortimer, M.C. Casimero, S.R. Obien, and S.K. De Datta. 2001. Reducing *Cyperus rotundus* tuber populations using stale-seedbed techniques in rice-onion systems. Proceedings of 18th Asian-Pacific Weed Science Society conference. Beijing, China. May 28-June 2, 2001. Pp. 215-223.

Gergon, E. B., Miller, S. A. and Davide, R. G. 2001. Root-knot disease of onion caused by the rice root-knot nematode *Meloidogyne graminicola*: Occurrence, pathogenicity, and varietal resistance. *Philipp. Agric. Scient*. 84:43-50.

Gergon, E. B., Miller, S. A., Davide, R. G., Opina, O. S. and Obien, S. R. 2001. Evaluation of cultural practices (surface burning, deep ploughing, organic amendments) for management of rice root-knot nematode in rice-onion cropping system and their effect on onion. *Int. J. Pest Mgt*. (in press).

Arida, G.S., B.S. Punzal, C.C. Ravina, V.P. Gapud, E. Rajotte and N.S. Talekar. 2001. Sex pheromones in pest management: Monitoring adult densities of *Spodoptera litura* (F.) and *S. exigua* (Hubner) (Lepidoptera: Noctuidae) in rice-onion cropping system. *PhilRice Technical Bulletin* (in press).

Awards

The work carried out in the Philippines site has been recognized by awards by several organizations during Year 8:

- Casimero, M.C., A.M. Baltazar, J.S. Manuel, S.R. Obien, and S.K. De Datta. 2001.
  Population dynamics and growth of weeds in response to control methods in rice-

onion cropping systems. Paper presented at the 18th conference of the Asian-Pacific Weed Science Society. Beijing, China. May 28-June 2, 2001. **Best paper award given by the Asian-Pacific Weed Science Society and Monsanto Chemical Company in Beijing, China on June 2, 2001.**

- Casimero, M.C. 2000. Population dynamics, growth and control of weeds in rice-onion cropping systems. Ph.D. Thesis. UPLB, College, Laguna. **One of three finalists in the Gamma Sigma Best Thesis Competition, March, 2001.**

- Gergon, E. B., Francisco, S. and Baltazar, A. 2001. **Finalist, Best Poster Award, Plant Pathology, PMCP Conference.**

- Gergon, E. B., Miller, S. A. and Davide, R. G. 2001. Root-knot disease of onion caused by the rice root-knot nematode *Meloidogyne graminicola*: Occurrence, pathogenicity, and varietal resistance. *Philipp. Agric. Scient.* 84:43-50. **Finalist, Philippines Dept. Of Agriculture-Bureau of Agricultural Research Best Published Paper Award, September 2001.**

CARIBBEAN REGION

Caribbean Site in Jamaica

Sue Tolin, Site Chair, Virginia Tech;
Dionne Clarke-Harris, Site Co-ordinator, CARDI

Description of the Collaborative Program

For the 2000-2001 project year, the activities of the Caribbean site were conducted mainly under the research components IPM Systems Development; Pesticide Use, Residues and Resistance; Social-economic, Policy and Production Systems; Research Enhancement through Participatory Activities. Research activities presented herein are the collective efforts of scientists from Caribbean and US Institutions including the Caribbean Agricultural Research and Development Institute (CARDI), Ministry of Agriculture (MINAG), Rural Agricultural Development Authority (RADA), Pennsylvania State University (PSU), Virginia Polytechnic Institute and State University (VPI&SU), Ohio State University (OSU) and United States Department of Agriculture Vegetable Laboratory (USDA-VL) .

To achieve the overall goal of the IPMCRSP in the Caribbean site, IPM system components have been tested over the last eight years to determine compatible combinations which would form the best management systems for major pests of hot pepper, sweetpotato, and vegetable *Amaranthus* or callaloo. Jamaica has been the primary host site, and regionalisation of some of the technologies developed by the research team of the site began in Year 6 and has since been a major emphasis.

The challenges to IPM systems development for the Caribbean have been linked to frequent use of toxic chemicals, which have

become ineffective against target pests. This pesticide-reliant mode of pest management poses high risks to human health and the environment. The IPMCRSP team has focussed on developing systems for rationalised pesticide use (sampling systems, decision support tools, new biorational pesticides and alternatives to pesticides.

IPM Constraints Addressed

Environmentally friendly biological controls and biorational pesticides were evaluated to determine potential candidates for management of hot pepper pests. The option of pest management, through virus resistant/tolerant cultivars, was used successfully with the introduction and promotion of the West Indies Red cv. in 1998. This has provided reliable industrial quantities while the more virus susceptible scotch bonnet was used to supply specialized markets.

Research was also designed to address the hypotheses that early infection of hot peppers reduced yield and quality of fruit, and that delaying infection would increase yield and quality. Correlations were made between increases in abundance of specific aphids and increased incidence of tobacco etch virus.

For callaloo, the current grower practices emphasize prophylactic calendar-based spray applications for control of lepidopteran larvae, resulting in high insecticide inputs. This results in high labor and material costs, minimizes the potential for integrating other management tactics, and creates environmental, health and export constraints. Developing action threshold-based spray application regimes have shown the potential to manage these insecticide inputs.

In addition, pesticides currently used against callaloo pests fail to give effective control, possibly because of the lack of resistant management protocols for pesticide use. New effective chemistries need to be identified and introduced in conjunction with the implementation of stricter management procedures for pesticide use. Available formulations are being evaluated for efficacy within a threshold-based spray application system. Since IPM ideally seeks to minimize pesticide use in production systems with the effective use of non-chemical methods, exclusion as a management option is also being evaluated.

Sweetpotato weevils, sweetpotato leaf beetles, and the WDS (Wireworm-*Diabrotica*-*Systena*) soil insect complex significantly reduce sweetpotato production in Jamaica and the rest of the Caribbean. The incorporation of pest management tactics, such as resistant breeding lines and the use of biorational insecticides, into the present IPM technology will greatly assist IPM procedures for sweetpotato farmers in the Caribbean to produce high quality products which are competitive in international markets. Dissemination of IPM technology to farmers in major sweetpotato growing areas in the Caribbean is on-going to facilitate the goal of reducing pest damage and improving sweetpotato production such that it is competitive in the global market.

Selected Research Accomplishments

- Subsequent to the promotion drive for the tolerant, 'West Indies Red' hot pepper variety during 1998 and 2000, the CARDI /IPM CRSP team was deemed the most qualified to render Technical Assistance to a USAID funded project in Walkers Wood, St Ann. In this community-based project, CARDI scientists advise a farmers group (14 farmers), producing approximately 12 acres of West Indies Red cv hot peppers, on enhanced hot

pepper production technologies (IPM, soil and water management and good agronomic practices). This project presents a linkage, which is beneficial to the IPMCRSP, as it creates a platform for disseminating IPM technology.

- For callaloo, two strategies (a) exclusion and (b) use of biorationals applied on the basis of pest density (1 larva per six leaf sample) have continued to give superior plant protection against Lepidoptera species, and in the case of exclusion, against all major pests. During Year 8, the benefits of these strategies have been demonstrated to an audience of 50 persons including farmers, extension officers of five major callaloo-growing districts in St Catherine, and representatives of chemical and Agro-supply companies.

- Exclusion and biorationals using a threshold-based spray application guide, the use of which gave significantly improved protection of the crop from insect damage when compared to farmer practice

- Initial analysis indicates that exclusion is most cost-effective in the summer months and the crop could then be established in uncovered locations during winter.

- Exclusion plots can be a pesticide-free system giving the product a competitive advantage, which could fetch a higher price.

- Biorationals applied using a threshold based spray guide consistently resulted in good economic returns, with profits ranging from 54%-165%.

- Exclusion as a management option can be maintained without the use of pesticides. However other compatible non-chemical tactics would enhance the system (sticky traps, soaps and oils and biopesticides).

- The threshold-based sampling plan demonstrated the potential to reduce frequency of pesticide applications by 46%-85%.

- The two pest management options developed for callaloo production systems are economically feasible

- Discussions have been held with research and other personnel in agricultural organisations in Antigua, St Kitts, Nevis, Trinidad and Barbados towards the regionalisation of the ‘callaloo research model'. The research approach, which was used in developing IPM systems for callaloo pests in Jamaica, is thought to be applicable to other vegetable systems throughout the region, in which high pesticide input is an important concern. The proposal is for this model to be tested on cabbage systems for developing management strategies against the diamond-back moth, *Plutella xylostella.* Plans for the regionalisation effort, entail a regional workshop to train researchers from relevant Caribbean countries. This workshop is slated for Year 9.

- Several dry-flesh sweetpotato breeding lines and varieties were evaluated at Blackville, SC; Charleston, SC, Homestead, Fla., St. Kitts and Jamaica, for resistance to soil insect pests, including sweetpotato weevils, sweetpotato leaf beetles, flea beetles, and the WDS (Wireworm-*Diabrotica-Systena*) complex. Of the 63 sweetpotato cultivars, breeding lines, and plant introductions evaluated at Charleston, SC, 39 entries showed high levels of insect (WDS) resistance. There was also significant

resistance to white grubs and flea beetles among the entries.

- Evaluation of yield and insect resistance traits of select USDA and Jamaican sweetpotato varieties, indicated that both local varieties (such as Tis30-30, Tis24-98, Fire-on-Land) and USDA varieties (e.g. White Regal and Picadito) may be included in IPM technology.

- Floral-lure baited traps have shown potential for incorporation into an IPM programme for sweetpotato. Traps placed in fields near Charleston, SC, Louisiana, North Carolina and inland areas of South Carolina captured either or both spotted cucumber beetle, *Diabrotica undecimpunctata*, and banded cucumber beetle, *D. balteata*.

- A sweetpotato weevil pheromone trap made from a 5-gallon bucket seen in Antigua was compared with six other traps. The funnel trap captured the most sweetpotato weevil adults, followed by the 5-gallon bucket trap and a trap described by Talekar (1988).

- The regionalisation component of the sweetpotato IPM under the project was continued after being initiated in Year 6. Researcher exchanges and visits to St Kitts and Nevis, and St Vincent provided the medium to initiate sweetpotato research and has set the stage for future expansion of the IPM CRSP research activities.

- Taxonomic studies on the gall midge species affecting hot pepper in Jamaica continue to give rise to questions. The most recent consultations between Gagne and Harris suggest that these species are neither the *Contarinia* species known to affect solanaceous plants nor any of the three groups of *Prodiplosis* described by Gagne 1995. This issue of pest identity is critical to our efforts and needs to be clarified as one of the priorities of the project.

- Further analysis of data collected from the islandwide survey of gall midge incidence and infestation levels has shown a significant positive correlation between size of plant canopy and total fruit infestation. From among the 12 parishes sampled during the survey, four production areas have been tagged as possible pest- free areas and will be monitored.

- A total of 83 field sessions were held in major hot pepper growing areas islandwide. These offered training in pest biology, economic importance and management tactics.

- Gall midge interceptions at Jamaica's two ports of exportation have decreased from over 100 cases in 1998 to just one case in 2000.

- A computer-based traceability system has been effected to be able to trace-back to farm origin of infested goods submitted for export. This system will be web-based by December 2001. An efficient inspection, monitoring and surveillance system is a requirement for the reversal of the mandatory fumigation imposed by USDA on hot peppers from Jamaica.

- During a Market study conducted in May 2001 a number of supply and support service issues were elucidated. Secondary market data showed that total weekly landing of scotch bonnet and habanero-type peppers through Florida is approximately 5,000-7,000-cases/ week. The market window for Caribbean

peppers is about 28 weeks between November and May while Caribbean pepper production peaks during May-September. Predominantly rain-fed farms, and possibly climate, are major factors effecting this lag in production. The market opportunity is further restricted by local hot pepper sources in the Mid –South and Border States and New Jersey as well as lower priced imports from Central and Latin America. These pointed to the need for Caribbean hot pepper producers to plan their production based on 70%-80% of produce going to the non-fresh (mash, frozen etc.) market with just between 20%-30% going to the fresh export market.

- Fumigation of hot peppers from Jamaica with methyl bromide is obviously and reportedly having serious negative impact on the quality and competitiveness of these peppers. A proactive program to get USDA to revisit the mandatory fumigation requirement is required in the short-term.

- Based on the recommendations coming out of this market study a proactive strategy was effected to influence USDA to revisit the mandatory fumigation requirement. This strategy has culminated in the planned visit (December 2001) of USDA delegates including a pest risk assessment expert to review monitoring and surveillance systems and field production practices.

- An interview of 30 importers/distributors, wholesalers and retailers showed a general lack of knowledge with respect to distinguishing among hot pepper varieties. A drive to educate these market entities in the distinctive characteristics of peppers originating from Caribbean sources can improve market share.

Technology Transfer

- Workshops focusing on various phases of crop management in hot pepper production were held in Walkers Wood, St Ann. During Year VIII, four workshops were held on (1) Seedling production (2) Land preparation (3) Soil and water management and (4) IPM. The 14 farmers in the farmers' group of the Walkers Wood community benefited from demonstrations and hands on training in aspects of these stages of production, which promote sustainability especially environmental conservation.

- One major callaloo field day was held in Linstead, St Catherine. This was the second in a series of workshops planned to demonstrate IPM systems to key callaloo farmers and extension officers in the callaloo growing belts in St Catherine. The theme of the field day was "Integrated Pest Management on callaloo- *Managing the development of insecticide resistance and using alternatives to pesticides*".

- A group of 50 agriculturists (key farmers and extension officers of five callaloo districts and representatives of chemical and agro supplies companies) were trained in:
  1. Integrated Pest Management and how it can be practiced in callaloo production.
  2. Identification of major callaloo pests and its importance in pest management.
  3. Using the sampling plan and decision making tool developed for lepidopteran larvae.
  4. Two new strategies for managing pests on callaloo were also demonstrated

- One workshop, at which 22 sweetpotato farmers and extension officers were trained, was held in Linstead, St Catherine

in December 2000. As a follow-up to this workshop, a field day was held in February 2001 on a demonstration plot in Old Harbour, St Catherine and 23 farmers and extension officers participated. At these technology transfer sessions, participants were exposed to an overview of IPM and IPM CRSP activities and achievements in the region, general principles and strategies of IPM, IPM of sweetpotato pests, the sweet potato weevil in particular, and the construction and placement of homemade pheromone traps.

- In April 2001, 19 Extension Officers and personnel from the Ministry of Agriculture, from the parishes of St Mary, St Ann and Clarendon participated in a one-day workshop and field day. They were trained in the identification of the pests of sweetpotato and strategies used in an IPM programme, and how to categorise the extent of damage by the major pests affecting sweetpotato in Jamaica. They also participated in an exercise to make pheromone traps and to place them in a sweetpotato field.

- To date over 500 farmers and extension personnel have participated in workshops throughout the Caribbean.

- In a four-day workshop in Jamaica, 21 agriculture related personnel were trained in the development and use of specialized software for web-GIS. Software is being modified for application in monitoring and surveillance of gall midge populations in Jamaica.

Networking Activities

- ❒ Drs Sue Tolin, Site Chair, and Clive Edwards visited Jamaica to conduct the in-country review and planning of the IPM CRSP Caribbean Site host country activities March 28-April 4, 2001.
- ❒ Frank McDonald, Dr Sue Tolin, D. Clarke-Harris, Dr D. Michael Jackson and Dr Shelby Fleischer participated in the IPM CRSP Annual Planning Workshop, Blacksburg Virginia, in May 16-19, 2001.
- ❒ Frank McDonald, D. Clarke-Harris, Vassal Stewart (CARDI) and Sam Scott (Consultant) conducted vists/study of hot pepper markets in Florida and New York, USA, in May 20-25, 2001.
- ❒ S. Tolin Site Chair and Dr Douglas Rouse visited Jamaica to conduct the External Evaluation of the IPM CRSP Caribbean Site host country activities (June 4-8, 2001)
- ❒ D. Clarke-Harris (CARDI) and Phillip Chung (RADA) coordinated and presented a farmer training session - Integrated Pest Management- managing the development of insecticide resistance and using alternatives to pesticides April 24, 2001.
- ❒ Shelby Fleischer and Software Engineer Bruce Miller travelled to Jamaica (April 17-20, 2001) to be resource persons in a workshop to develop a web-based GIS system for monitoring gall midge in Jamaica.
- ❒ D Clarke-Harris and Drs. D. Michael Jackson and Kathy M Dalip presented the Workshop on Integrated Pest Management of Sweetpotato, 8-9 November 2000, St. John's, Antigua and to assist in the regionalization of sweetpotato IPM technology to the eastern Caribbean.
- ❒ D Clarke-Harris and KM Dalip presented the Workshop on Integrated Pest Management of the West Indian Sweetpotato Weevil, *Euscepes postfasciatus* Fairmaire, in St Vincent and the Grenadines on November 19-22, 2000, in Dumbarton, St Vincent.
- ❒ Dr. Jackson presented a poster on the IPM CRSP project at the Annual Meeting of

the Entomological Society of America 3-7 December 2000, Montreal, Canada.

- ❒ Dr. Janice Bohac attended the National Sweetpotato Collaborators Meeting, 27-31 January 2001, Ft. Worth, TX.
- ❒ Dr. Bohac attended the 39th Annu. Sweet Potato Convention, 28-30 Jan. 2001, Orange Beach, AL.
- ❒ D Clarke-Harris and Drs. Lilory McComie and Kathy M Dalip presented the Workshop on Integrated Pest Management of the Sweetpotato Weevil, *Cylas formicarius* L., March 21 2001, Nevis.
- ❒ KM Dalip (CARDI) and Phillip Chung (RADA) coordinated and presented a workshop for RADA extension officers on the Integrated Management of Sweetpotato Pests, with emphasis on the Sweetpotato Weevil, *Cylas formicarius* L. at Ebony Park, St Catherine, Jamaica on April 12, 2001.
- ❒ Drs Jackson and Bohac served as members of the Sweetpotato Crop Germplasm Committee.

Regionalization of IPM Technology

The focus on the regionalization component continued in Year VIII. Hence, four Caribbean countries were visited during the reporting period in order to assist sweetpotato farmers in the region to improve the quantity and quality of sweetpotato being produced by initiating the introduction of IPM technologies which have demonstrated potential in Jamaica.

Sweetpotato IPM

St Kitts

The results of the evaluation of 10 lines (USDA and local) of sweetpotato for tolerance to the sweetpotato weevil, *Cylas formicarius*, were consistent with those of the trial carried out in Year 7. The local lines of sweetpotato grown were more tolerant to stem and root damage by *C. formicarius* under the dry exposed field conditions that existed during the trial. However, the trial has to be repeated in different ecological zones in St Kitts.

Evaluation of storage potential of 10 sweetpotato lines under ambient conditions in St Kitts revealed that nine of the 10 lines investigated showed weevil damage by both *C. formicarius* and *Eucepes postfasciatius* after one month in storage. Although *E. postfasciatus* was previously recorded in St Kitts and Nevis, this was the first time in the two and a half years of current work that such high populations of the weevil were seen on harvested roots. Some lines began to sprout from as early as two weeks in storage and after two months, many lines showed 100% sprouting e.g. Mandela I, 'Local', Never Miss, Sugar Root II and Sumor. While 50% or more of seven varieties were discarded after two months in storage, only 33.3% of the line Clarke and 37.5% of Regal were discarded two months after being stored.

The comparison of crop loss data in May 2000 and March 2001 showed that, by employing recommended IPM technology introduced in May 2000 on one farm in St Kitts, weevil damage was reduced from 31.1% to 7.7%.

Nevis

Eighteen farmers and extension officers participated in workshop held in March 2001. They were informed on the different pests of sweetpotato, how to identify damage by these pests and how to reduce damage caused by these pests using cultural and physical control strategies. They were also shown how to construct homemade sweetpotato weevil

pheromone traps using recyclable plastic containers.

Antigua

At a workshop in November 2000, farmers and extension officers were informed of the cultural practices effective against the sweetpotato weevil. They were also trained in the making of homemade traps.

St Vincent

Twenty-seven extension officers and farmers participated in training workshop held in November 2000 during which they learned to identify weevil, grub and rat damage to tubers, the application of different complementary cultural practices effective against sweetpotato weevils and the construction of sweetpotato weevil pheromone traps using plastic containers.

Extensionists were also trained in the assessment of damage to stems and tubers due to different pests and the construction of pheromone traps using plastic containers.

Vegetable IPM

Discussions were also held with relevant agricultural personnel in Antigua, Barbados, St Vincent, St Kitts, Nevis and Trinidad to plan for a regional workshop on developing IPM for vegetable systems with high pesticide input. In some of these countries cabbage farms affected by diamondback moth were visited.

Impacts

Sweetpotato is an important crop for many countries in the Caribbean both as an export product and as a staple of the diet of the local citizenry. Several similarities exist among the islands (Jamaica, St Vincent, St Kitts and Nevis) e.g. pest complex. Under the sweetpotato IPM component, the identification of several sweetpotato varieties (e.g. local varieties Tis30-30, Tis24-98 and Fire-on-Land and USDA varieties White Regal and Picadito) and the potential inclusion of environmentally friendly chemicals (e.g. garlic extract), as well as floral lure traps in addition to the sweetpotato weevil pheromone traps) which may be included in an IPM technology are positive moves towards the ultimate goal of reducing pest levels on the crop, such that the quality and quantity of sweetpotato in the Region can be improved and the commodity can become competitive in international markets

The dissemination of IPM as a component of sustainable hot pepper production continued through technical assistance request made of the CARDI/IPMCRSP in Jamaica. These types of spin off linkages allow for wider dissemination and adoption of the IPM approach.

Activities in the strategy to combat gall midge on hot peppers in Jamaica have resulted in a better understanding of the behaviour and biology of this pest. Monitoring and surveillance systems to allow efficient interception and trace back of infested peppers submitted for export have been implemented. These systems allow for identification of pest free seasons, hot spots and pest free zones. Based on progress to date, USDA delegates will be visiting Jamaica, during December 2001 to carry out investigations to review the position of mandatory fumigation of hot peppers against this pest.

The two management systems (1) exclusion of major pests of callaloo using a row cover 70% light transmission in combination with cultural practices and (2) use of new biorational pesticides against lepidoptera

larvae based on a sampling strategy, have been demonstrated to farmers. these systems show the potential to reduce pesticide input by 46%-100%. This reduction represents a major impact on export acceptability, consumer safety and environmental protection production costs.

Market studies conducted under the project has increased the awareness of major issues affecting the trade of hot peppers to the USA and has indicated the way forward in addressing some issues with respect to supply and support services.

To date approximately 200 callaloo farmers and extension agents have benefited directly from the IPM CRSP training exercises in managing callaloo pests.

EASTERN EUROPEAN REGION

Eastern Europe Site in Albania

Douglas G. Pfeiffer, Site Chair, Virginia Tech;
Josef Tedeschini, Site Coordinator, Plant Protection Institute, Durres

Description of the Collaborative Program

The IPM CRSP Albania Site is a collaboration of the Plant Protection Institute (Durress), the Fruit Tree Research Institute (Vlora) and the Agricultural University of Tirana, and scientists from IPM CRSP USA Institutions. The program in Uganda operates under a Memorandum of Understanding with Ministry of Agriculture and Food (MOAF). The in-country Site Coordinator located at PPI is Dr. Josef Tedeschini.

There are 12 scientists at Albanian institutions involved with the CRSP, with several disciplines spread across the institutions (entomology, plant pathology, horticulture, and agricultural economics. PPI: Enver Isufi, Brunhilda Stamo, Harallamb Pace, Vangjel Jovani, Bujar Huqi, Josef Tedeschini; FTRI: Dhimiter Panajoti, Hajri Ismaili, Mendim Baci, Bardhosh Ferraj, and Zaim Veshi; AUT: Fadil Thomaj, Myzejen Hasani, Rexhep Uka and Magdalena Bregasi. American scientists involved are Douglas Pfeiffer (site chair; Virginia Tech), Charles Pitts (Penn State Univ.), Beth Teviotdale, Louise Ferguson and Milt McGiffen (Univ. of Calif.).

Olive is a major crop in Albania. Olives are used mainly for olive oil, but a significant part of the crop is produced for table use. In 1996, the country produced 27,660 metric tons of olives. The total number of olive trees increased from 2,931,000 in 1994 to

3,405,000 in 1996. In recent years, olive production has been quite low because of problems associated with a low knowledge base of the farmers, as well as limited resources. Furthermore, olive quality has been poor because of high levels of pest injury.

The main pests were identified during the participatory appraisal process in 1998. The main insect pests of olive are: olive fruit fly, *Bactrocera oleae* (Gmelin), olive moth, *Prays oleae* Bern., Mediterranean black scale, *Saissetia oleae* Olivier, and olive psyllid, *Euphyllura olivina* Costa. The main diseases of olive in the region are: olive knot, *Pseudomonas syringae* pv *savastonoi* (E. F. Smith) Stevens, olive leaf spot, *Cycloconium oleaginum* Cast., and *Cercospora*. Additionally, there are weed problems resulting from a range of annual, biennial, and perennial species. This combination of pests causes great reductions in yield and crop quality, yet growers are unable to exert control measures.

One of the most important determining factors in olive oil quality is olive fruit fly. This species shows very high levels of infestation in Albanian olive groves. Currently, because growers cannot afford to spray for OFF, black scale is successfully controlled by a complex of naturally occurring parasites. A central challenge for the project is to develop means of controlling OFF without disruption natural controls for black scale. In addition, it is a goal of this project to examine the economic effects of various IPM tactics developed during the course of the project, and to explore marketing options for Albanian olive producers.

The Year 8 work plan was focused on crops, pests and constraints identified in the participatory appraisal process (1998). The research projects included:

- Meeting the Educational and Planning Needs for Olive Integrated Pest Management,
- Monitoring of Crop Pests and Their Natural Enemies in Olive Production Systems,
- Effect of Harvest Timing on Olive Fly Infestation and Olive Oil Yields and Quality
- Vegetation Management,
- Effect of Pruning on Olive Production, Infestation by Black Scale and Incidence of Olive Knot and Timing of Copper Sprays to Control Olive Leaf Spot and Olive Knot
- Pheromone-Based IPM in Olive and Effects on Non-Target Species,
- Project Economic Impacts of Albania IPM CRSP Research Activities

The primary field research site is at Shamogjin, a research farm under the control of FTRI.

IPM Constraints Studied

The main constraints to olive IPM that are addressed by this research are:

- Lack of knowledge among growers on basic aspects of pest and beneficial species biology.
- Gaps in knowledge in Albania on species composition of additional pests and in beneficial species complex,
- Lack of supplies for normal pest management programs
- Lack of marketing infrastructure (markets, price incentives for pest-free crop, etc.)

Selected Accomplishments

The following are examples of key results obtained in the Albanian site.

The main research IPM activities during 2000-2001 were done at the Experimental Station of FTRI (Shamogjin) in the Vlora Region. Field surveys were conducted for the incidence of arthropod pests, diseases, nematodes and weeds in olive orchards. Different pheromones were tested for the monitoring of key pests. Population dynamics of olive month and olive fruit fly were further clarified; more information is now available to better control the main pests of olive crop. New pheromones for monitoring the presence of *Palpita unionalis* Hb. and *Zeuzera pyrina* L. were used for the first time in Albania. Three new mite pests of olive and a natural enemy of olive fruit fly were identified in collaboration with University of Bari, Italy.

Data were collected to estimate the actual fruit damage by olive moth. A high level of olive moth infestation was observed particularly on cultivars KMB and Kalinjot. Olive fruit fly infestation remained as the predominant insect pest problem impacting olive fruits. Severe olive infestation is generally associated with significant losses especially in early ripening olive cultivars. Different varieties have shown different levels of infestation.

The preliminary results on the population dynamics of Mediterranean black scale showed that it has one generation per year and the insect could probably develop a partial autumnal generation. The survey indicated that black scale overwinters as first, second and third instar nymphs. The eggs were laid during June with a peak of population development in mid June. Heavy natural mortality of nymphs was caused by high temperatures and low humidity of summer. Our understanding of the role of natural enemies in maintaining black scale below the economic threshold level has improved. Parasitism rates of *Scutellista cyanea* (a natural enemy of black scale) were very high in several places and the activity of the parasitoid *Metaphycus* sp., causing high mortality of black scales in olive, was clearly demonstrated. Normally a low level of pest population was observed due to extensive cultivation of olive orchards. Another scale species, *Aspidiotus nerii* (Bouche), was found in olive orchards during autumn, and in the spring; infestations of *Euphyllura olivine* (Psyllidae) were also common.

Among the eriophyid mites living on olive trees, *Aceria oleae*, *Ditrymachus athiasella*, and *Tegolophus hasani* were the common species in Vlora region and *A. oleae* was almost always predominant. The most susceptible cultivar was Kalinjot, with maximum infestation on leaves and fruits in May and September. This mite represents another pest that will be included in our efforts to develop IPM approaches.

Observation made in olive orchards revealed again the presence of leaf spot and olive knot as two more important diseases of olive trees in Vlora district. Severe defoliation of olive trees due to the fungus *Mycocentrospora cladosporioides* Sacc, the causal agent of the cercosporiosis, has been observed in the experimental orchard during April. The most susceptible variety was Frantoi. The presence of Verticillium wilt was also identified on KMB and Mixan varieties and in some asymptomatic trees in Berat region. The incidence of olive knot was 5.4 galls / m^2 of canopy and field monitoring showed that the higher level of leaf spot disease appeared during March-April.

During this year eight genera and eight species of nematodes were identified in olive groves and nurseries. The most common of the plant parasitic nematodes were *Xiphinema pachtaicum, Helicotylencus vulgaris,* and *Pratylenchus thornei*. In the root samples, *Rotylenchus macrodoratus*, was identified, whereas the most important in olive nurseries were *Helicotylenchus pseudorobustus* and *Pratylencus thornei.*

To develop an effective weed control strategy, measurements of weed density and identification of dominant species has been conducted in olive trees area in Shamogjin. The dominant species among the shrubs were *Dittrichia viscose* (L. W. Greuter and *Rubus ulmifolius* Shott, among the grasses *Koheleria gracilis* (L.), *Bromus* sp. (L.*),* and sp. (L.), and among broad-leaved weeds *Centaurea solstitialis* (L.) *, Trifolium* sp., *Medicago* sp. (L.), *Arum italicum* (L.), *Cirsium arvense* (L.), etc. The number of weeds estimated in monitored area varies from 250-430/ m^2

In general all the data collected from this year's activities will serve to develop models that can be used to forecast pest outbreaks and establish acceptable levels of chemical pesticide use. These will be used as a basis for the development of an IPM system.

Mutuality of Benefits of the Research

Fruit specialists in Albania receive training in modern techniques of biological control, fruit production, and the implementation of IPM in a free market context. A non-disruptive IPM program for olive will be developed. For U.S. specialists, there is an opportunity to see a perennial crop with pests similar to theirs (olive fruit fly similar to apple maggot, Mediterranean black scale similar to terrapin scale, etc), in a setting of reduced pesticide availability. Groundwork for future collaboration is established.

Institution Building

Funds provided by the IPM CRSP –Albania supported the research programs of the three institutions by supporting technical staff, travel to research sites, and providing equipment for each of the three institutions (microscopes, computers, water still, etc.).

Human Resource Development

One graduate student is currently supported through the Albania IPMCRSP site, Lefter Daku, in the Department of Agricultural and Applied Economics at Virginia Tech. It is expected that Mr. Daku will finish in Jan. 2002. It is planned to bring a second student to the Department of Entomology next year.

Networking Activities

Several workshops have been supported by our project that disseminated results to olive producers and other researchers.

Workshop on "Improvement of olive oil quality, a task for the Albanian export" (Dhermi May 17-19, 2001). In collaboration with World Learning-USAID Project, IPMCRSP/Al project paid $2000 for the organization of workshop. There were 40 participants from Albania, Italy and Greece. Our specialists have given 5 presentations regarding the IPM/CRSP results in olive and the new technologies of olive cultivation.

Meeting (15-22 May, 2001) Blacksburg-Virginia Tech J. Tedeschini and Dh. Panajoti.

Participation in workshop "Cooperation between Albania-Italy for the development of organic agriculture" (11-12 September, 2001, Tirane-Vlore). In this meeting, the contribution of our project toward the development of organic agriculture on olive and the new technique of vegetation

management in organic olive groves were presented. There were about 60 specialists from Albania and different research Institutions from Italy. The participants have visited our experimental fields in Shamogjin to see the organic production system in olive, the mass-trapping technique for OFF control and the application of copper treatment to control olive diseases. Our presentations and some other results of our project will be published in the proceedings of workshops in Albanian and Italian.

In cooperation with AAATA, AOA and CEFA (an Italian NGO) on June 19 in Elbasan region a workshop about new technologies of cultivation and protection of olive crop was organized. Four presentations were prepared from our project and 65 participants (Albanian growers, extension officers, other specialists) have received the materials and leaflets prepared by our colleagues.

In cooperation with AOA and with the funds of World-Learning Project we have conducted 3 workshops/demonstrations and distribution of 4000 Eco-traps to facilitate the understanding of the tactic and to improve the control of OFF in four main regions of olive cultivation. Leaflets were prepared explaining the techniques of mass-trapping (September 2001).

In the workshop organized by AOA on 17-18 September-Vlore on the technologies of olive oil production, two presentations were made by our specialist (Effect of harvest timing.... and Mass trapping technique) and printed materials were distributed.

Technology Transfer

Organization of statistical short course with Penn State University February 26-March 2. Twelve specialists from PPI, FTRI and AUT participated.

BOARD OF DIRECTORS

The annual IPM CRSP Board of Directors meeting was held at Virginia Tech on 9 - 10 April 2001. Attendees were:

Appointed members:
David Sammons (Chair; Purdue University), Robin Huettel (USDA), S.K. De Datta (Virginia Tech), Tom Mew (International Rice Research Institute), Steve Slack (representing Bob Moser; Ohio State University), Paul Backman (Penn State University), Richard Robbins (North Carolina A&T University), Zahurul Karim (Bangladesh Agricultural Research Council), Frank Zalom (University of California).

Ex-Officio members:
Brhane Gebrekidan (Program Director, IPM CRSP, Virginia Tech), Greg Luther (Assistant Program Director, IPM CRSP, Virginia Tech), Robert Hedlund (Project Manager, IPM CRSP, USAID).

Technical Committee Representative:
George Norton (Chair of Technical Committee, IPM CRSP, Virginia Tech).

S.K. De Datta (Principal Investigator, IPM CRSP) gave the Welcome Address and Report to the Board, entitled, "Relevance of the IPM CRSP in the New Millennium."

Major decisions made by the Board included:

- The Minutes of the Board of Directors Meeting of 29-30 March 2000 were approved as they stood.
- The Board Chair recognized the international partners for their implicit and explicit cost sharing.
- The Board endorsed the Management Entity (ME) providing leadership, through the Technical Committee (TC), for this CRSP to be involved in biotechnology-related activities in accordance with the directive from USAID. The TC will guide this process. This is based on the recognition that enhancing the understanding of biotech under CRSP leadership is of global significance.
- The Board recommends that the ME set aside a minimum of $250,000 per year out of new money for the next 5 years for biotechnology research.
- A letter will be sent out by the Board Chair to the IPM CRSP consortium universities, asking them to take on more responsibility in terms of filling Site Chair positions. The letter should lay out the responsibilities of a Site Chair clearly. Also included will be a statement that it is necessary for Site Chairs to attend the annual TC Meeting.
- The IPM CRSP may need to provide further resources to the Site Chairs for administrative and coordinating activities to make the position less burdensome and more enticing.
- The Board Chair will write letters to or call Site Chairs who have not attended recent meetings to persuade them to attend.
- The Board endorsed the principle that collaborative research requires multi-institutional involvement (among IPM CRSP partners) and directed the ME, through the TC, to ensure all sites involve multiple institutions in a proactive way. The Board directed the ME, through the TC, to ensure this performance criterion is met before funds are released.
- There was a consensus to let the minutes show that the IPM CRSP is making efforts to recruit HBCU scientists, the Board applauds the ME's and Site Chairs' efforts, and the Board encourages the ME and Site Chairs to continue these efforts. This CRSP has done well in this regard, but we still need more HBCU involvement.

- A gender specialist should be placed on the TC, and this will mean an additional position is being added to the TC.
- There is a need to recognize the spectrum of outputs in publication form from discovery to implementation to dissemination, and all of these are important, particularly for an activity like the IPM CRSP that is charged with showing impact over the relatively short term.

Minutes of the Board Meeting are available on request from the IPM CRSP ME.

TECHNICAL COMMITTEE

The IPM CRSP Technical Committee (TC) held its main annual meeting at Virginia Tech in Blacksburg, Virginia, on May 16 - 19, 2001. Technical Committee members for Year 8 of the IPM CRSP were:

George Norton, TC Chair, and Site Chair, Asian Site in Bangladesh
Sally Miller, Site Chair, Asian Site in the Philippines
Mark Erbaugh, Site Chair, African Site in Uganda
Rezaul Karim, Host Country Site Coordinator Representative
Keith Moore, Site Chair, African Site in Mali
Sue Tolin, Site Chair, Caribbean Site in Jamaica
Glenn Sullivan, Site Chair, Central American Site in Guatemala
Jeff Alwang, Site Chair, South American Site in Ecuador
Doug Pfeiffer, Site Chair, Eastern European Site in Albania
Michael Irwin, External TC Member
Colette Harris, Gender Specialist
Aziz Lagnaoui, International Agricultural Research Center Representative
S.K. De Datta, Principal Investigator, IPM CRSP
Brhane Gebrekidan, IPM CRSP Program Director
Greg Luther, IPM CRSP Assistant Program Director
Bob Hedlund, IPM CRSP Project Manager, USAID

In addition to the Technical Committee Meeting, a Symposium was held to initiate the process of writing a book based on the IPM CRSP. A poster session was also held to present site research progress. In addition to TC members, host country Site Coordinators and many other co-PIs attended the Symposium, poster session, and Year 9 Planning Meetings at Virginia Tech.

In this May 2001 meeting the IPM CRSP Executive Committee (a subcommittee of the TC) met and made the following decisions:

- By next year the EC should come up with a set of criteria for performance and delivery of performance.
- The EC recommended each Site Chair receive $6000 to use in whatever way they think is best to manage their site**.**
- The minimum amount for a prime site has been increased to $132,000.

The TC approved the following budget distribution across sites for Year 9 of the IPM CRSP:

Site / Activity	***Year 9 budget***
Guatemala	$ 179,000
Philippines	$ 189,000
Jamaica	$ 136,000
Mali	$ 184,000
Uganda	$ 234,000
Bangladesh	$ 244,000
Ecuador	$ 239,000
Albania	$ 160,000

Global Themes	$ 34,000
Biotech	$ 255,000

Other major decisions made by the TC include the following:

- The Executive Committee should review proposals, based on merit, for allocation of Global Themes monies for travel of co-PIs to other sites. An invitation from a site to an individual should be part of this process. The ME should receive the proposals, which will then be forwarded to the EC for review.
- George Norton was unanimously voted in as TC Chair.
- Sally Miller rejoined the EC by consensus of the TC.

The minutes for these meetings are available on request from the IPM CRSP ME.

EXTERNAL EVALUATION PANEL (EEP) REVIEWS

The current members of the IPM CRSP External Evaluation Panel (EEP) are Sonny Ramaswamy, Kansas State University, Chair; Shelley Feldman, Cornell University; Donald Plucknett, Agricultural Research and Development International; and Douglas Rouse, University of Wisconsin. During Year 8 the members of the EEP completed site visits of all eight IPM CRSP prime sites and submitted appropriate site evaluation reports (Table 1). The primary purpose of each visit was to evaluate the progress and the status of the IPM CRSP activities in the site visited.

The findings and evaluation results of the EEP members are documented in the individual site reports which have been submitted to the USAID IPM CRSP Project Manager, Dr. Robert C. Hedlund. The eight site reports are available with the IPM CRSP ME as well.

The EEP met in Blacksburg November 19 and 20 as a group to discuss the eight individual site reports and listen to additional verbal reports from EEP member(s) visiting each of the sites, rationalize the individual reports, and arrive at a collective EEP position report which can stand as in-depth EEP global review for Phase II of the IPM CRSP. The in-depth EEP report is expected to be submitted before the end of December 2001.

TRIP REPORTS, YEAR 8

Trip reports from Year 8 of the IPM CRSP totaled as follows:
Antigua: 2; Bangladesh: 2; Ecuador: 4; Guatemala: 2; Jamaica: 1; Mali: 6; Philippines: 2; St. Vincent: 1; Uganda: 1. These reports are all posted on the IPM CRSP web site,
http://www.ag.vt.edu/ipmcrsp/

Table 1. 2001 Schedule for IPM CRSP EEP Site Visits and Reports

Trip No.	Country	EEP Member	Dates of Travel, 2001	Date Report Submitted
1	Philippines	Doug Rouse	Jan. 20-27	May 21, 2001
2	Bangladesh	Doug Rouse and Shelley Feldman	Jan. 27 - Feb. 1	August 7, 2001
3	Albania	Don Plucknett	Mar. 4-10	Apr. 6, 2001
4	Guatemala	Don Plucknett	Mar. 18-24	Apr. 16, 2001
5	Ecuador	Sonny Ramaswamy	Mar. 18-24	Apr. 23, 2001
6	Uganda	Don Plucknett	Apr. 15-25	May 3, 2001
7	Jamaica	Doug Rouse	Jun. 3-8	Nov 19, 2001
8	Mali	Sonny Ramaswamy	Jul. 14-21	Jul 26, 2001

Publications, Presentations and Other Products of the IPM CRSP

Cumulative Compilation through May 14, 2001

Category	*General / Other*	*Albania*	*Bangladesh*	*Ecuador*	*Guatemala*	*Jamaica*	*Mali*	*Philippines*	*Uganda*	*Total*
Papers Published in Refereed or Reviewed Publication	0	0	0	1	7	20	6	13	11	58
Books/Book Chapters	0	0	0	0	2	0	0	0	0	2
Theses and Dissertations	0	0	0	8	8	3	3	4	2	28
IPM CRSP Annual Reports and Highlights	10	0	0	0	0	0	0	0	0	10
Extension Publications (large)	0	0	1	0	4	10	1	4	4	24
Proceedings (not refereed or reviewed)	14	0	0	0	66	14	10	42	16	162
IPM CRSP Working Papers	2	2	0	1	3	0	3	8	2	21
World Wide Web Sites and Documents	2	1	0	0	0	3	0	0	0	6
Germplasm Releases	0	0	0	0	0	6	0	0	0	6
Workshops, Courses, Field Schools and Field Days	0	0	1	17	28	11	9	10	13	89
Papers/Seminars Presented	0	1	0	13	61	34	22	31	68	230
Electronic Presentations	0	0	0	0	0	4	0	0	0	4
Posters	1	0	0	0	3	19	1	20	2	46
Fact Sheets (small ext. pubs.)	0	0	0	0	0	1	0	16	4	21
Newsletters	17	0	0	0	0	2	1	2	3	25
Videotapes	0	0	0	0	0	1	4	1	0	6
Magazine and Newspaper Articles	0	0	0	0	1	0	0	2	3	6
Reports	36	14	42	44	158	153	98	132	79	756
Abstracts	0	0	0	0	2	8	1	2	4	17
Bibliographic Databases and Miscellaneous	0	0	0	0	0	0	0	6	0	6
TOTAL	82	18	44	84	343	289	159	293	211	1523